GEOLOGY AND GEOSITE POTENTIAL OF KARSTS IN KAMPUNG BATU UDANG, DABONG DISTRICT, KELANTAN

By

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

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DECLARATION

I declare that this thesis entitled "**GEOLOGY AND GEOSITE POTENTIAL OF KARSTS IN KAMPUNG BATU UDANG, DABONG DISTRICT KELANTAN"** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

"I/We hereby declare that I/ we have read this thesis and in my/our opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Applied Sciences (Geosciences) with Honours."

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Geology and Geosite Potential of Karsts in Kampung Batu Udang, Dabong District, Kelantan

ABSTRACT

This study is about the geology and geosite potential of karsts in Kampung Batu Udang, Dabong District, Kelantan by using the Modified Geosites Assessment Model (M-GAM). The purpose of this study is to update the geological map of Kampung Batu Udang at Dabong with a scale of 1:25,000 based on interpretation and to give exposure to the uniqueness of karst features at Kampung Batu Udang located in the Dabong District of Kelantan that is known for its karst formations. The area is situated in the eastern portion of the country and is known for its unique limestone formations and caves. The geology of the area is primarily composed of Paleozoic and Mesozoic rocks, including sandstones, shales, and limestones. The limestone formations in the area are believed to be of Late Permian to Early Triassic age. The study area contains unique karst geomorphology and geomorphological structure to conduct research and surveys. The M-GAM is a tool used to evaluate geosites and includes both main values (MV) and additional values (AV) based on the Geosite Assessment Model (GAM). It considers the views of two different groups, which can affect the final assessment of the geosite. The study area's geological map has been updated, and the M-GAM assessment of high values indicates the suitability of geosite potential with a high-value indicator of scenic and aesthetic for MV and for AV was touristic values. This is because these values are seen as important to visitors who are looking for attractive and visually pleasing landscapes, as well as opportunities for recreation and tourism activities. The high score for these values shows that the study area may have a strong potential for development as a geosite, attracting visitors and potentially boosting local economies. These results suggest that the area has the potential to attract tourists and visitors due to its unique and visually appealing geomorphological features.

Geologi dan Potensi Geotapak Karst di Kampung Batu Udang, Daerah Dabong, Kelantan

ABSTRAK

Kajian ini adalah mengenai geologi dan potensi geotapak karst di Kampung Batu Udang, Daerah Dabong, Kelantan dengan menggunakan Model Penilaian Geosite Diubahsuai (M-GAM). Kajian ini bertujuan mengemaskini peta geologi Kampung Batu Udang di Dabong dengan skala 1:25,000 berdasarkan tafsiran dan memberi pendedahan tentang keunikan ciri-ciri karst di Kampung Batu Udang yang terletak di Daerah Dabong, Kelantan yang terkenal dengan formasi karst. Kawasan ini terletak di bahagian timur negara ini dan terkenal dengan formasi batu kapur dan gua yang unik. Geologi kawasan ini terutamanya terdiri daripada batuan Palaeozoik dan Mesozoik, termasuk batu pasir, syal, dan batu kapur. Formasi batu kapur di kawasan itu dipercayai berasal dari Permian Lewat hingga Zaman Triassik Awal. Kawasan kajian mengandungi struktur geomorfologi dan geomorfologi karst yang unik untuk menjalankan penyelidikan dan tinjauan. M-GAM adalah alat yang digunakan untuk menilai geotapak dan merangkumi kedua-dua nilai utama (MV) dan nilai tambahan (AV) berdasarkan Model Penilaian Geosite (GAM). Ia menganggap pandangan dua kumpulan yang berbeza, yang boleh menjejaskan penilaian akhir geotapak. Peta geologi kawasan kajian telah dikemas kini, dan penilaian M-GAM yang bernilai tinggi menunjukkan kesesuaian potensi geotapak dengan penunjuk nilai tinggi pemandangan yang indah dan estetik untuk MV dan untuk AV adalah nilai pelancongan. Ini kerana nilai-nilai ini dilihat penting kepada pengunjung yang mencari landskap menarik dan visual yang menyenangkan, serta peluang untuk aktiviti rekreasi dan pelancongan. Skor tinggi bagi nilai-nilai ini menunjukkan bahawa kawasan kajian mungkin mempunyai potensi yang kuat untuk dibangunkan sebagai geotapak, menarik pengunjung dan berpotensi meningkatkan ekonomi tempatan. Keputusan ini menunjukkan bahawa kawasan ini berpotensi untuk menarik pelancong dan pelawat kerana ciri geomorfologinya yang unik dan menarik secara visual.

TABLE OF CONTENTS

TITTLE	**PAGE**

TITTLE	PAGE

TITTLE	PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

∑	Total
%	Percentage
′	Minutes
″	Seconds
×	Multiplication
<	Less than
/	Slash
∑	Summation
=	Equal
+	Plus

LIST OF ABBREVIATION

E	East
W	West
N	North
S	South
GIS	Geographic Information System
GPS	Global Positioning System
km	Kilometres
m	Metres
PPL	Plane Polarized Light
XPL	Cross Polarized Light

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General Background

The term “geoheritage” refers to areas or region with geologic features that have significant scientific, educational, cultural, or aesthetic value. Geoheritage site can include classic geographic features and landscapes, distinctive rock, or mineral types, unusual or uncommon fossils or other geological properties that are useful for scientific study and research. Geoheritage sites must consist of geological features or landscapes that represents any process or historical geology such as landscapes that are visually appealing owing to its geological features, process and etc. Many geoheritage locations are potentially developed to become tourism attraction which gives local and regional economic advantages (National Academies of Sciences, Engineering, and Medicine et al., n.d.).

Geoheritage sites are also of great public interest especially for geoscientists. Dabong location is critical for advancing information on groundwater availability, soil practises, climatic and biological changes, mineral and vitality supplies, life development, and various aspects of the Earth’s ecology and history. Dabong area also offer a strong potential for usage as open-air study halls, promoting open understanding of science, recreational use, and economic assistance to surrounding communities. Furthermore, geoheritage is an essential component of geological heritage since it includes unique places and artefacts that contribute to our understanding of the earth's nature such as rock, minerals, fossils, and ecosystems. Geoheritage also is an important aspect of geotourism expansion (Mohd. Shafeea Leman et al.).

The state of Kelantan includes a variety of intriguing geological locations and features with potential geoheritage and geotourism such as Dabong which has a popular geotourism destination notable for its Gua Ikan Complex. The method used for this assessment is M-GAM model which derived from GAM (Geosite Assessment Model) that emphasized the opinion of experts and visitors. The geological mapping and geoheritage mapping were conducted as to gathered data about geoheritage value.

1.2 Study Area

Based on Figure 1.1 and Figure 1.2, both shows the location map of study area with the base map that includes a few elements such as the river and main road. The research was carried out at the district of Dabong, in Kampung Batu Udang area. A 5 × $5km^2$ box was filled approximately 25 km per square.

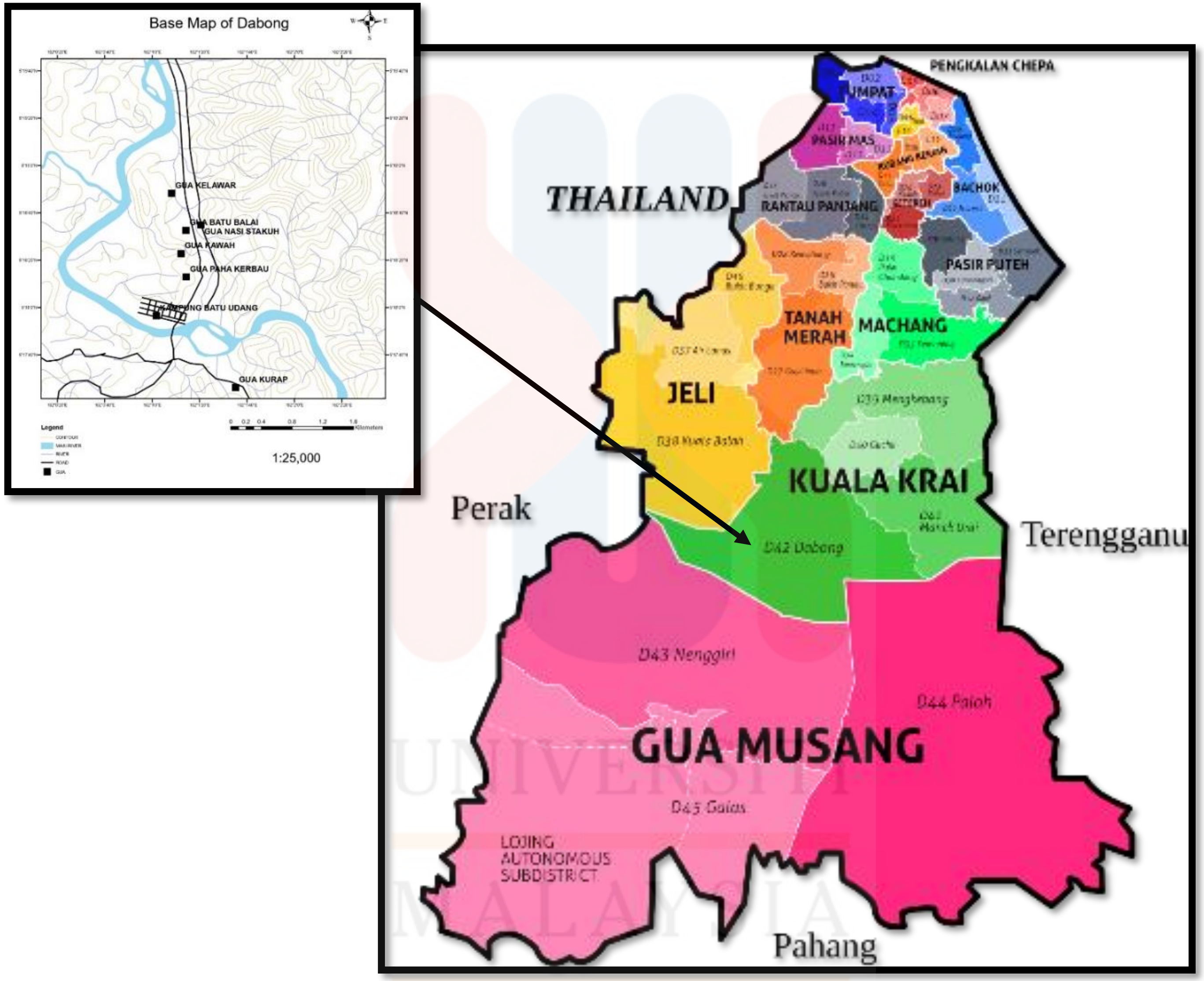

Figure 1.1: Location map of study area.
Source**:** (Phang et al., 2020)

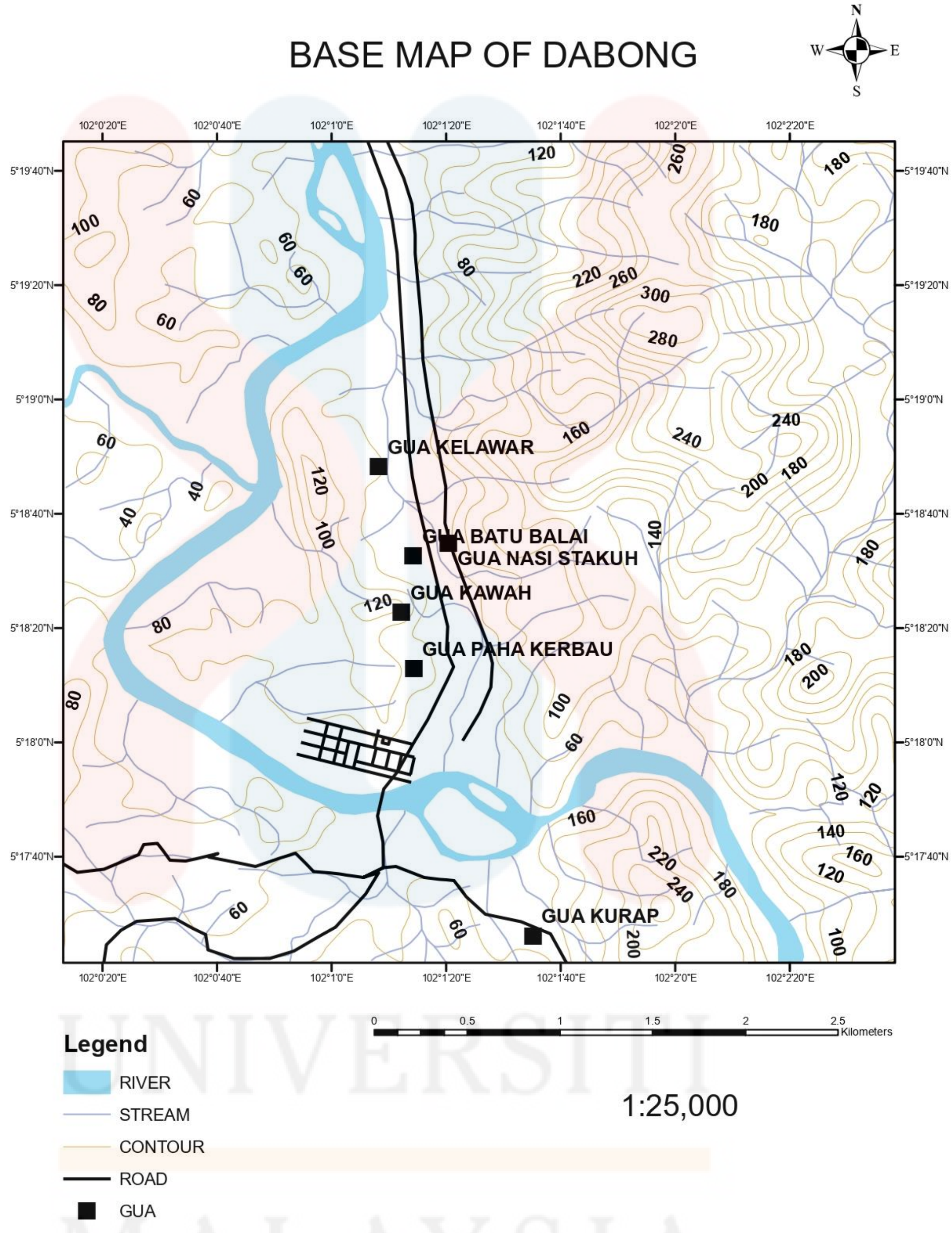

Figure 1.2: Base Map of Dabong.

1.2.1 Location

The research is conducted at Kampung Batu Udang at Dabong district in the region of Kelantan, Malaysia. The study area is located within the latitude of 5.3769° N and longitude of 102.0098° E. Refer Table 1.1 for coordinates of studied karst.

Table 1.1: Coordinates of studied karst.

Geoheritage Potential Karst	**COODINATE**	
	LATITUDE	**LONGITUDE**
1.GUA KELAWAR	5°18'48.20"N	102° 1'8.20"E
2.GUA NASI STAKUH	5°18'34.80"N	102° 1'20.40"E
3.GUA BATU BALAI	5°18'32.60"N	102° 1'14.20"E
4.GUA KAWAH	5°18'22.80"N	102° 1'12.20"E
5.GUA PAHA KERBAU	5°18'12.90"N	102° 1'14.30"E
6.GUA KURAP	5°17'26.20"N	102° 1'35.10"E

1.2.2 Road Connection / Accessibility

There are two main roads that connects Jeli and Dabong which is the route at KM13 Jalan Jeli-Dabong near Kg Reka and KM34 Jalan Jeli-Dabong near the Kuala Balah Road Transport Department. The study area can be reached from Jeli via both main roads stated above. With the assistance of a good availability, the area of research can be entered.

1.2.3 Demography

Kuala Krai is covering an area of 2,287km^2 which includes the population density of 45.91/km^2 with annual population changes starting from year 2010 until 2020, had given about 0.070%. From the source of Department of Statistic Malaysia, the population structure is divided into four parts which are gender, age groups, urbanization, and religion. All the data are gathered within the year of 2020. For gender, there were 52 863 males and 52 144 females. Within the age group, there were divided into three parts which are 0-14 years, 15-64 years, and also 65 years and above. These three parts have consisted of 30 366, 67 826 and 6 815. For urbanization section, it was divided into two part which are rural and urban. The rural are contains with 77 959, whereas for urban was 27 048 ("Department of Statistics Malaysia Official Portal").

In 2020, there were 99 601 Muslim, 275 Christian, 3 562 Buddhist, 922 Hindu, for other religion and no religion were counted as 73 and 1. Other places in Kuala Krai are includes Dabong, which covered around 825.2km^2 had a population of 13 796 with population density of 16.7km^2 (Kuala Krai District, n.d.). Figure 1.3 was showing the above data through the pie chart according to its types and Table 1.2 was showing the data of mid-year population estimate time series and gender in Kelantan from year of 2015 until 2020 ("Department of Statistics Malaysia Official Portal").

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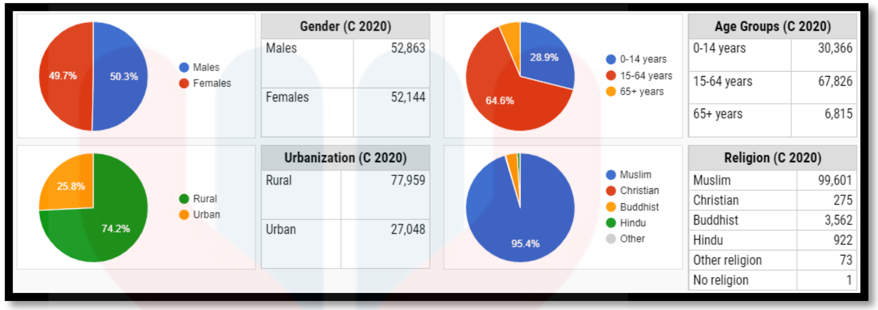


Figure 1.3: Pie chart with the information about the population structure.

Source: ("Department of Statistics Malaysia Official Portal")

Table 1.2: Mid-year population estimate time series and gender in Kelantan, 2015-2020.

State	Gender	2015	2016	2017	2018	2019	2020
Kelantan	Male	887.6	906.7	923.2	939.9	952.1	962.8
	Female	873.0	890.1	905.8	920.6	931.7	942.1
	Total	**1,760.6**	**1,796.7**	**1,829.0**	**1,860.5**	**1,883.8**	**1,904.9**

Source: (Department of Statistics Malaysia Official Portal, n.d)

1.2.4 Land-use

Land-use involves the management and alteration of natural or wasteland area in built environments such as villages and semi-natural landscapes e.g., arable land, pastures, and forest management. It was also described as the overall arrangements, activities, and inputs that people undertook in a specific form of land cover. The dominant land-use in Dabong is forestry and dense forest. In the study area are also covering with small area of uncultivated land, palm oil, settlement area, scrub land and mixed horticulture. Figure 1.4 (a) and (b) are representing the land use and land cover map of Kelantan. The red circle on each figure was showing location of the study area.

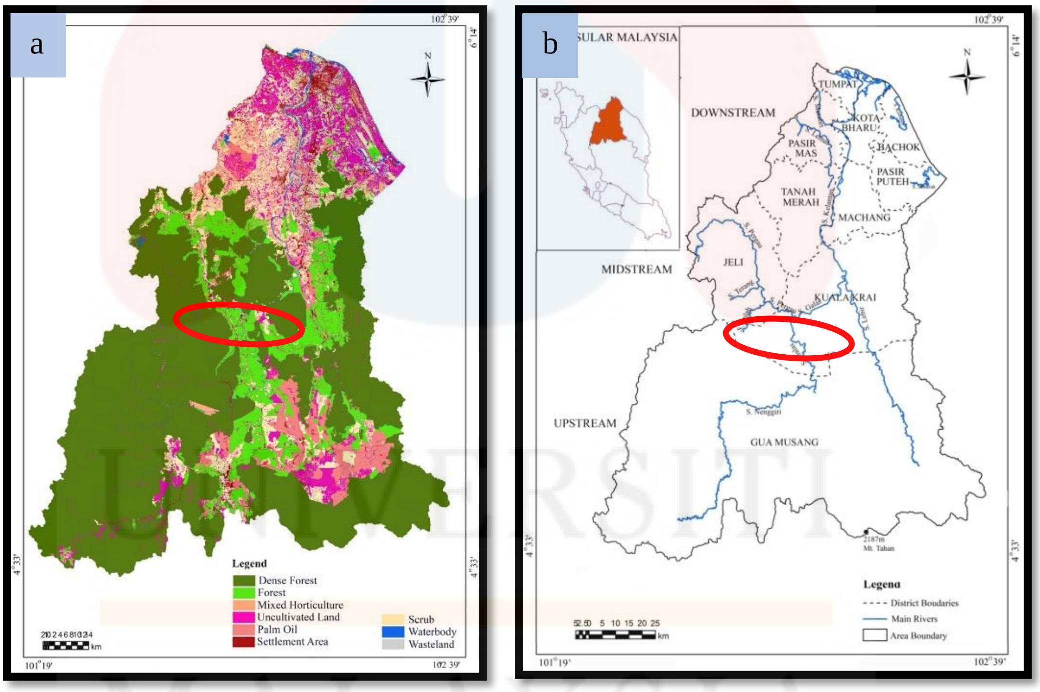


Figure 1.4: (a) Land use and land cover map (LULC) of 2015, (b) Base map of Kelantan. Source: (Anees et al., 2017)

1.2.5 Social Economic

Based on socioeconomic report on the year of 2020, Kelantan Gross Domestic Product (GDP) was decreased by (-1.1%), refer Table 1.4 (Department of

Statistics Malaysia Official Portal, n.d.). However, presently Kuala Krai is experiencing rapid growth which has contributed to some extent in GDP value. The rapid growth experienced in Kuala Krai was because of the good urbanization effect that offers potential native and outsider jobs.

Data of economic growth and economic activity in Kelatan which including agriculture, mining and quarrying, manufacturing, construction, and services have been stated in the Table 1.3 below with data of GDP starting with the year of 2019 until 2020. These general data from Department Statistic Malaysia will representing the socioeconomic of Kelantan, as the Dabong socioeconomic was less mentioned in any research paper or journal, website and etc.

Table 1.3: Kelantan economic growth and economic activity in year 2019 until 2020.

State	**Economic Activity**	
Kelantan	Agriculture	0.2
	Mining & quarrying	-12.8
	Manufacturing	-5.1
	Construction	3.5
	Services	-1.0
GDP 2020	**-1.1**	
GDP 2019	**5.6**	

Source: (Department of Statistics Malaysia Official Portal, n.d.)

1.3 Problem Statement

Kampung Batu Udang is a small village located in the Dabong District of Kelantan, Malaysia, that is known for its karst formations. These karst formations, which are characterized by limestone rocks that have been weathered and eroded by the action of water, can be found throughout the area and are of great interest to geologists and other earth scientists (“Karst,” n.d.).

However, despite their importance, little is known about the geology and geosite potential of these karsts. This research aims to address this gap in knowledge by investigating the geology and geosite potential of the karst formations found in Kampung Batu Udang.

This research was conducted using a combination of field and laboratory techniques, including mapping and petrological analysis. The results of this research will provide valuable information about the geology and geosite potential of karst formations in Kampung Batu Udang, Dabong District, Kelantan, which can be used to guide future research and management efforts in the area.

1.4 Objective

a. To produce geological map of Kampung Batu Udang, Dabong with the scale of 1:25,000 based on interpretation.
b. To evaluate 6 caves for potential geoheritage value of Kampung Batu Udang by using M-GAM method.

1.5 Scope of Study

The research was focus on producing a detailed geological map of Kampung Batu Udang, Dabong at a scale of 1:25, 000 based on interpretation of field data. The map had provided information on the geological formations, structures, and mineral occurrences in the area, which will be useful in understanding the geology and geosite potential of the karst formations.

Other than that, this research had evaluated six caves in Kampung Batu Udang for their potential geoheritage value by using the M-GAM method, a standard evaluation method for geosites. This will help to identify the most significant caves for conservation and management. Furthermore, the research was also considered all other scientific and non-scientific data that could be gathered through the research such as literature, local community knowledge and observations that provide a complete understanding about the geosite potential of the karst in Kampung Batu Udang, Dabong District, Kelantan.

1.6 Significance of Study

The geological map of Kampung Batu Udang and surrounding areas would provide an important baseline dataset for the understanding of the geology and geomorphology of the area, which would be beneficial for future research in the area.

The evaluation of caves for their geoheritage value would help to identify caves that are of significant scientific and cultural value and would help in the planning of conservation and management strategies for these caves, to promote sustainable development of the area. Additionally, this research would also provide a detailed understanding of the geosite potential of the karst in Kampung Batu Udang, Dabong District, Kelantan which could inform the development of sustainable geotourism activities in the area.

The use of GIS to integrate the data collected in the research would allow a better understanding of the distribution of the karst features, geology, and geomorphological processes in the area, as well as of the different areas with different potential value for geotourism and preservation.

CHAPTER 2

LITERATURE REVIEW

2.1 General Background

Karst's area a type of landscape that are characterized by the presence of limestone rocks that have been weathered and eroded by the action of water. They are typically characterized by the presence of sinkholes, caves, and other features such as limestone-based features which had formed by the weathering process ("Karst," n.d.). Kampung Batu Udang is a small village located in the Dabong District of Kelantan, Malaysia, that is known for its karst formations. The area is situated in the eastern portion of the country and is known for its unique limestone formations and caves (Sulaiman et al., 2020).

Karst landscapes are known to have formed due to chemical weathering of limestone rocks by rainwater that is slightly acidic. Limestone is composed mainly of calcium carbonate (CaCO3) which dissolves easily in weakly acidic solutions, leading to the formation of solution channels and caverns. As a result of dissolution, the rock breaks down and erodes, leading to the formation of characteristic karst features such as sinkholes and caves ("Karst," n.d.).

In Malaysia, karst landscapes have been observed in several locations, including the Kinta Valley in Perak, the Gua Tempurung, and the Lenggong valley. A number of studies have been conducted on the karst landscapes in these areas, focusing on their geology, geomorphology, hydrology, and speleology. However, few studies have been conducted specifically on the karst formations in the surrounding area of Dabong District, Kelantan (Fatihah, 2010).

In terms of geotourism potential, the unique features of karst landscapes and the caves found within them can be a popular destination for tourists. Additionally, karst landscapes can provide important habitats for a wide range of plant and animal species and are important for the ecological balance. Therefore, understanding the geology and geosite potential of karst in Kampung Batu Udang, Dabong District, Kelantan, is important for its preservation and for the development of sustainable geotourism activities in the area (Ruban, 2018).

2.2 Regional Geology and Tectonic Setting

Peninsular Malaysia is divided into three longitudinal belts which are Eastern Belt, Western Belt, and Central Belt due to the collision of Sibumasu and Indochina plate tectonic in Late Permian to Triassic period, refer Figure 2.1 (Hutchinson & Tan, 2009). Each belt has different stratigraphy, mineralization, structures, geology, and the distribution of rocks (Mohamed et al., 2016). Its distribution is depended on the geology and the distribution of rocks (Fischer, 1990). Orogenesis process occur as the result of the collision between Sibumasu with Indochina plate tectonic. From the tectonic event, many variations of stratigraphy and geological history of Peninsular Malaysia had been produced (Hutchinson & Tan, 2009).

The regional geology and tectonic setting of Kampung Batu Udang and the surrounding area in Dabong District, Kelantan are characterized by a complex history of tectonic activity and sedimentation. The area is part of the Peninsular Malaysia, which is located on the Sunda Plate, the southern extension of the Eurasian plate. The Peninsular Malaysia is situated on the boundary of the Sunda plate and the Eurasian plate has experienced complex tectonic activity throughout its history (Hutchinson & Tan, 2009).

The geology of the area is primarily composed of Palaeozoic and Mesozoic rocks, including sandstones, shales, and limestones. The limestone formations in the area are believed to be of Late Permian to Early Triassic age. These rocks were likely deposited in a shallow marine environment, and later uplifted and folded as a result of tectonic activity. The tectonic setting of the area is also characterized by the presence of major regional faults such as the Bentong-Raub Suture Zone, which marks the boundary between East Malaya Block and the Indochina Plate to the west. The suture zone is believed to have formed during the Late Triassic and Early Jurassic as a result of the collision of the Indochina Plate with the East Malaya Block. The collision led to the uplift and erosion of the rocks, which in turn provided the necessary conditions for the formation of karst landscapes (Metcalfe, 2000).

It's worth noting that the area is also affected by the monsoon rains that occur during the rainy seasons, which can be a contributor to the formation of karst landscapes. The rainfall can create a percolating effect in the limestone causing dissolution, cave formation and other karst features (Gupta, 2005). Overall, the regional geology and tectonic setting of Kampung Batu Udang, Dabong District, Kelantan, Malaysia, are characterized by a complex history of tectonic activity and sedimentation, with the uplift and erosion of limestone rocks believed to have provided the necessary conditions for the formation of karst landscapes ("Karst," n.d.). More studies that focus on the area specifically would give a more accurate understanding of the geology and tectonic setting of the karst formations found in Kampung Batu Udang.

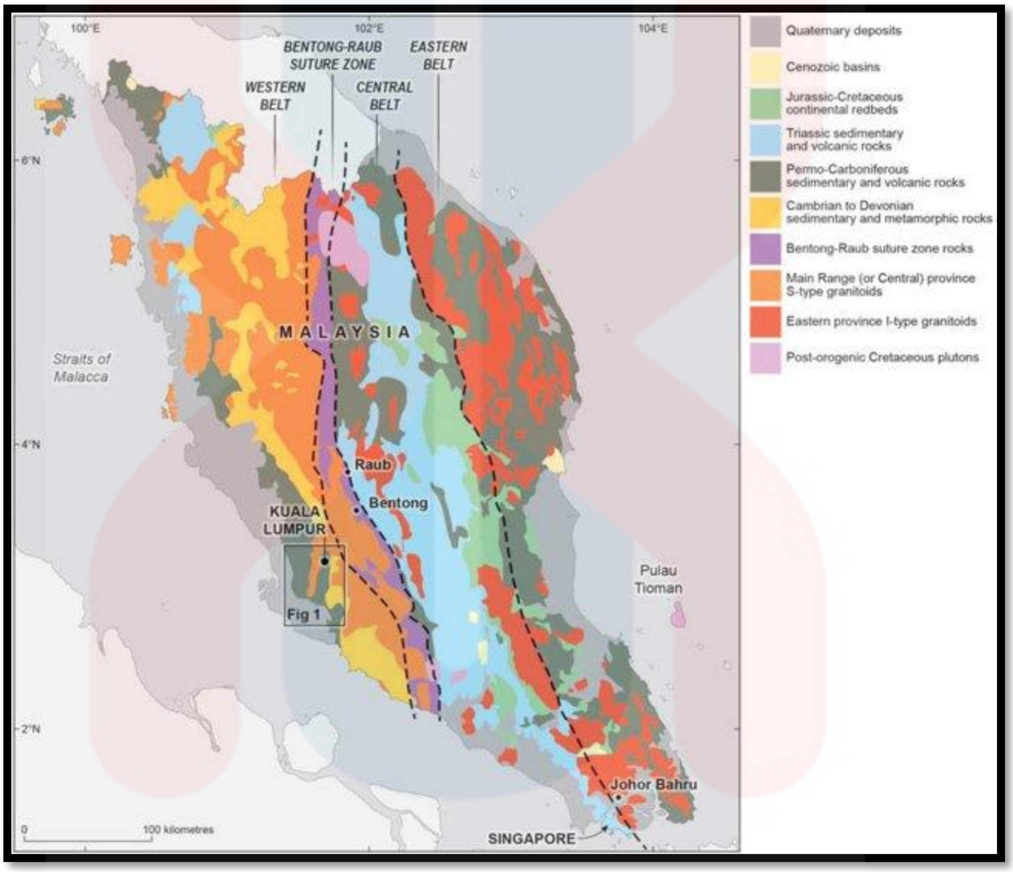


Figure 2.1: Regional geological map of Peninsular Malaysia.

Source: (Leslie et al., 2020)

The eastern Peninsular Malaysia is located to the east of Bentong-Raub Suture which also known as "East Malaya Block". However, it is now considered as southwards extension of Indochina terrane with different in tectonostratigraphy and evolution to the Sibumasu terrane (Metcalfe, 2000). There was a line in Bentong-Raub Suture that separated the Western Belt from the Central Belt. A long line which extending from Thailand towards East of Malacca is known as North-South long line lineament. This long line lineament is also produced a trend of deformed rocks

(Hutchison & Tan, 2009). Within the Peninsular Malaysia, there are two major fault which is known as Lebir Fault (borders the Eastern and Central Belt) and Bentong-Raub line (borders the Central and Western Belts) (Hutchison & Tan, 2009) refer to the Figure 2.2.

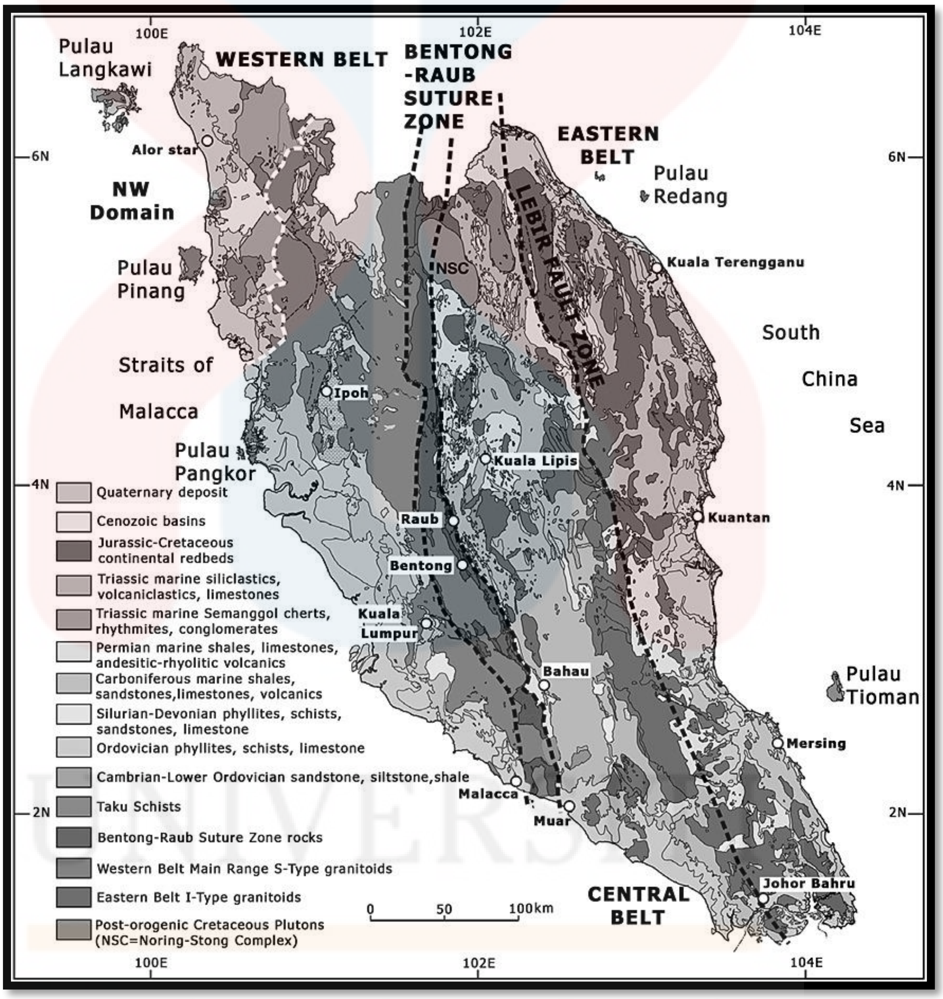


Figure 2.2: Lebir fault line and Bentong-Raub Suture line in Peninsular Malaysia.

Source: (Pour et al., 2016)

In the state of Kelantan, there are four distribution of the rock types and the effect of weathering (Quarry Resources Planning for the state of Kelantan, 2003). The geology of Kelantan can be classified as shows in Table 2.1.

Table 2.1: Rock types in the state of Kelantan.

<table>
<tr><th>Rock Type</th><th colspan="2">Area</th></tr>
<tr><td>Granitic rocks</td><td>33%</td><td rowspan="4">Total: 15 022 km^2</td></tr>
<tr><td>Sedimentary/metasedimentar yrock</td><td>51%</td></tr>
<tr><td>Extrusive rocks (volcanic rocks)</td><td>10%</td></tr>
<tr><td>Unconsolidated sediment</td><td>6%</td></tr>
</table>

Source: (Quarry Resources Planning for the state of Kelantan, 2003)

Approximately 15,022$km2$ of Kelantan state are cover by all type of rocks. Sedimentary/metasedimentary rock is the highest percentage and the prevalent type of rock which occupies the Kelantan north-south central portion. The distribution of granite rocks was categorized into two granite provinces, the Main Range Province, and the Eastern Province. These two provinces were separated by the Bentong-Raub Suture zone. The granites of the main range and boundary range bordered the state on the west and east respectively. At the north-south direction, these belts of granite and other country rocks trend and truncated to the north by unconsolidated sediments of Kelantan Alluvial Plain (Azman, 2000).

Specifically, the Eastern Province granite is made up of I-type granite that forms of smaller batholiths of zone and unzone plutons (Hutchison & Tan, 2009). The pluton was developed during the Permian to Triassic period. It intruded in sequence of mudstone, siltstone, limestone, sandstone and in a thick sequence of intermediate to acid volcanic and volcaniclastic rocks (Hutchison & Tan, 2009). Eastern granite has a composition which ranging from gabbro to monzogranite characterized by its texture from equigranular to weakly porphyritic texture (Ghani, 2008). Additionally, this province was dominated with hornblende and biotite (common mafic phase occur up to 1 cm size) (Ghani, 2008).

In Kelantan, the oldest rock unit occurred was during Silurian-Ordovician Period, meanwhile for depositional process, it is continuing occurred in Carboniferous, Permian, Triassic, Cretaceous-Jurassic and Quaternary succession as shown in the Figure 2.2. The study area, Dabong is situated in Kuala Krai at the southern part of Kelantan state that is made up of Gua Musang Formation which had deposited during the Early Permian to Late Triassic. It was bounded by Stong complex form the Main Range Granite and it has vicinities of acid intrusive igneous rocks, sedimentary rocks, and metamorphic rocks (Metcalfe, 2013).

Gua Musang Formation is consisting with argillaceous and calcareous rocks that interbedded with volcanic rock. Whereas for arenaceous rocks, it only consists in minor amount (Mohamed et al., 2016). This formation also has crystalline limestone with interbedded argillites and subordinate sandstones (Yee, 1983). In argillaceous rock units, it has shale, siltstone, mudstone, slate, and phyllite (Mohamed et al, 2016). The geology of southern part of Kelantan state is divided into three parts which are the lower Paleozoic rocks (located at the west part of southern Kelantan), Permian-Triassic rocks (located at the middle part of southern Kelantan), and the Jurassic-Carbonaceous rocks (located at the eastern part of southern Kelantan) (Mohamed et al., 2016).

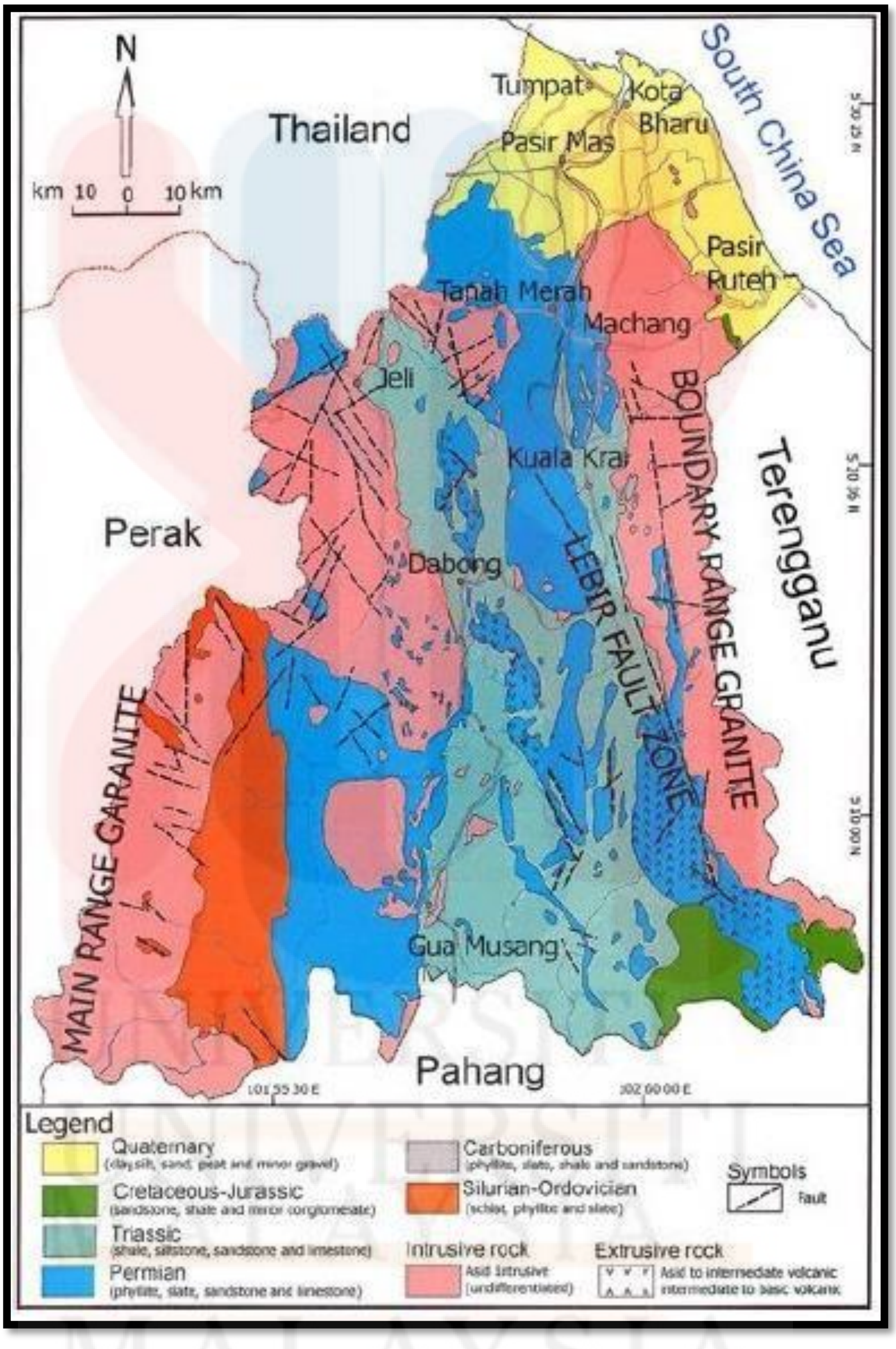


Figure 2.3: Geological map of
Peninsular Malaysia.
Source: (Minerals and Geoscience Department Malaysia, 2013)

2.3 Stratigraphy

In Northwest and Central Belt of Peninsular Malaysia was where the Mesozoic rock formations was found, however very less was found in the Eastern Belt of Peninsular Malaysia. In Peninsular Malaysia, they were 38 of Mesozoic rock formations and from the number, 28 were formation from onshore Peninsular Malaysia, 8 formation which from West Sarawak and 1 each formation from Sabah and the offshore Malay Basin. Mesozoic rock formations were consisting of Chuping Limestone, Semanggol and Kodiang limestone formation in northwest Peninsular Malaysia, and the Gua Musang, Aring and Telong formations in the Central Belt which also known as parts of inseparable lithostratigraphic unit from Late Paleozoic in (Permian) to Early Mesozoic (Triassic) (Metcalfe, 2013).

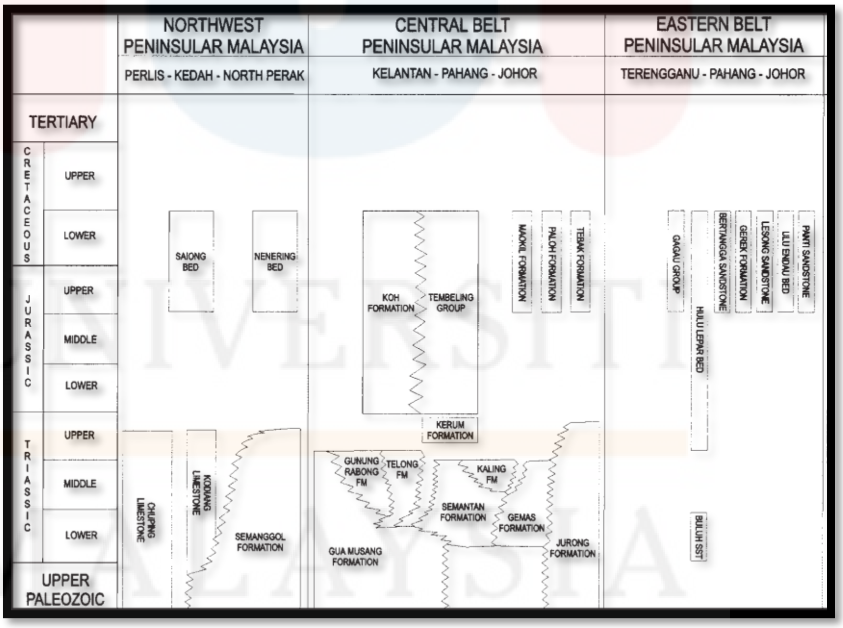


Figure 2.4: Correlation chart for Mesozoic rock formation in Peninsular Malaysia.

Source: (Jabatan Mineral Dan Geosains Malaysia)

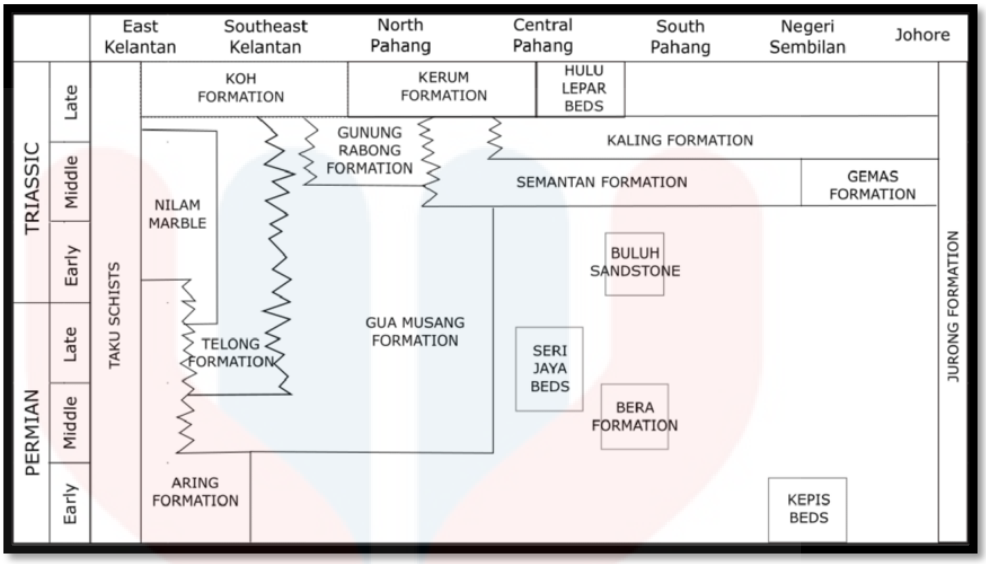


Figure 2.5: Permo-Triassic stratigraphic correlation chart of Central Belt in Peninsular Malaysia.
Source: (Mohamed et al., 2016)

Mesozoic rock formations in Malaysia were grouped together in different geographical and paleoenvironmental setting. Thus, correlation between the regions mostly proven error by the used of lithological correlation comparing it with the fossil’s occurrences. However, the formations were very well correlated within the same paleoenvironment and geographical settings. Some areas had a natural occurring formation together as a group, such as Gagau, Tembeling and Raub Groups in the Central Belt of Peninsular Malaysia. Marine Triassic sediments in the Central Belt are more tuffaceous than the rocks with the same age in Western Belt (Chai Peng Lee and Geological Society of Malaysia. Malaysian Stratigraphic Central Registry Database Subcommittee).

Additionally, in Gua Musang, Aring and Gunung Rabong Formations of the Permo-Triassic in Kelantan and northern Pahang were dominated by the shallow marine clastics and carbonates with volcanic interbeds. The Gunung Rabong formation was overlain with the Gua Musang Formation. It is consisting with primarily argillaceous and calcareous intercalation of volcanic. Whereas in the south of Gua

Musang, there was consisting with arenaceous rocks. For fossil appearance, ammonoids and pelecypods which were found in Permian to Middle Triassic period (Chai Peng Lee and Geological Society of Malaysia. Malaysian Stratigraphic Central Registry Database Subcommittee)

2.4 Structural Geology

The state of Kelantan was located at the northeastern region of the Peninsular Malaysia. From the tectonic event that occurred within the Peninsular Malaysia in Paleozoic and Mesozoic era, resulting in the formation of folding and faulting. During the tectonic activity, the joints will form when the rock is uplifted, folded, and fractured. Joint will form without the removal of shear and occurs when tensile stress exceeds its threshold (Nursufiah Sulaiman et al., 2020).

2.5 Historical Geology

During the intrusion of the Stong Complex, the metamorphic rocks in Dabong was formed to low metamorphism contact which responsible for formation of schist and marble that found in the foot hill of Stong Complex. The major rocks type that made up Kelantan were sedimentary and metasedimentary rock which formed during the aged of Ordovician to Cretaceous (Pour and Hashim). In Dabong area has a distinct morphological features such as hills, and karstic morphology in the limestone regions. Kelantan also have four types of geomorphological which is mountainous, hilly, plain, and coastal regions (Tanot et al., 2001).

The Gua Musang Group is a significant geological unit in Malaysia that provides important insights into the region's tectonic and sedimentary history. Comprised of a variety of rock types, including sedimentary, volcanic, and igneous rocks, that were formed during the Mesozoic era, it has been the subject of many previous research efforts. This section in research study aims to provide a comprehensive overview of the geologic history of the Gua Musang Group, including its stratigraphy, sedimentology, and tectonic setting, with the hope of gaining a better understanding of the geological processes that have shaped the region over millions of years (Mohamed et al., 2016).

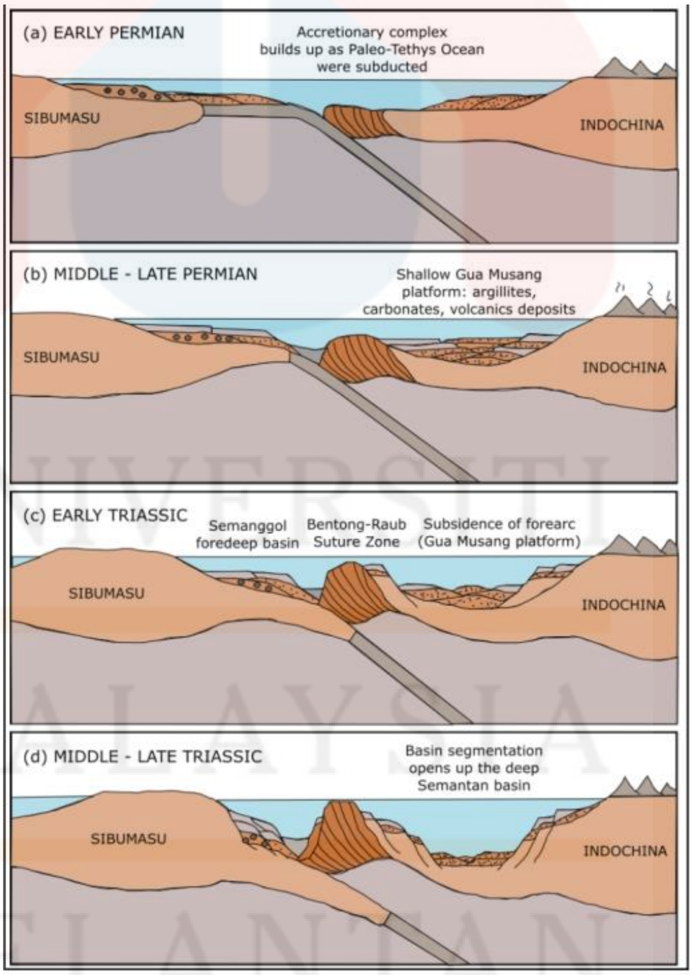


Figure 2.6: Illustration of geologic history of Gua Musang Group.

Source: (Mohamed et al., 2016)

Referring to the Figure 2.6, the figure is showing the geological history of Gua Musang Group development from Early Permian to Late Triassic. In figure, label (a) was showing a thick of argillite and volcanic which also known as Aring and Telong formations that had deposited adjacent to Indochina volcanic arc, whereas the Paleo-Tethys Ocean was subducted during the Early Permian. In figure label (b) was showing a thick of argillite and volcanics which had been created by the Gua Musang platform known as the shallow marine environment. This Gua Musang platform are suitable for carbonate development during the Middle Late Permian due to the suitable of shallow marine environment in Gua Musang platform. The Gua Musang formation was begun starting from the east. Thus, the volcanism peaks while the forearc basin was started to subside. In figure label (c), during the Early Triassic, the forearc basin was undergone an intense subsidence in Gua Musang platform which had resulting in the creation of many spaces which for the deposition of carbonate argillite (Mohamed et al., 2016).

The subduction of Sibumasu resulting in closure of Paleo-Tethys Ocean completely stopped when Sibumasu and Indochina terrane were collided. In figure label (d), during the Middle Late Triassic, on the subsiding of Gua Musang platform, an oblique subduction of Sibumasu was occurred due to the process of basin segmentation on it. The process had resulting in the formation of the deep marine Semantan-Gemas basin. This Semantan-Gemas basin was bounded by the shallow marine platform same as how it had been portrayed now by the geometry of Central Belt as we observed today. The cause of the presence of slump deposits and Raub, Kota Gelanggi, and more were from the basin faulting and segmentation (Mohamed et al., 2016).

2.6 Research Specification

The study of karst geology and geosite potential has a long history, dating back to the early 19th century when the term "karst" was first used to describe the distinctive landscapes and geological features found in limestone regions. The study of karst landscapes gained importance during the 20th century, as geologists began to recognize the unique features of these landscapes and their importance for groundwater resources, cave systems, and biodiversity (Ford & Williams, 2007).

In recent years, the study of karst geology and geosite potential has continued to develop and expand, driven by advances in geological mapping, remote sensing, and geospatial analysis. The application of new technologies and methods has allowed for a more detailed understanding of the complex geological processes and features that characterize karst landscapes (Hoblea et al., 2014).

One of the latest developments in the study of karst geology and geosite potential has been the use of 3D modeling and visualization techniques to better understand the three-dimensional structure of karst landscapes. This has allowed researchers to better analyse and visualize the spatial distribution and connectivity of features such as sinkholes, cave systems, and underground rivers (Cheng et al., 2019).

Another important development has been the increased recognition of the importance of karst landscapes for conservation and tourism. Many karst landscapes are home to unique and threatened species of flora and fauna, and their distinctive features have significant cultural and historical value. As a result, there has been a growing focus on the development of sustainable tourism and management strategies for karst geosites (Day & Urich, 2000; Gillieson, 2005).

Overall, the study of karst geology and geosite potential continues to be an active and evolving field, with ongoing research and development focused on improving these unique and important landscapes.

Research on the geology and geosite potential of karsts can have several rationales. Firstly, it can contribute to our understanding of the complex processes that shape karst landscapes, such as the formation of sinkholes, caves, and underground rivers. This can help advance our knowledge of these unique geological features and may have implications for other fields such as hydrology and geomorphology.

Secondly, research on the geosite potential of karsts can help identify areas that may be of particular scientific, cultural, or recreational interest. Karst landscapes are often characterized by unique flora and fauna, cultural heritage sites, and geological formations that can have significant value for conservation, tourism, and other forms of land use. By identifying these areas, research can help inform the development of sustainable management and protection strategies, which can benefit both local communities and broader society.

Thirdly, research on the geology and geosite potential of karsts can have practical implications for regional development. Karst landscapes are found in many parts of the world and can be important for local economies and communities. By providing information on the potential economic, cultural, and scientific benefits of these landscapes, research can contribute to regional development efforts and promote the sustainable use of these resources.

In summary, the rationales for conducting research on the geology and geosite potential of karsts are multifaceted, ranging from advancing our scientific understanding of these unique landscapes to identifying areas of cultural and economic value, and promoting sustainable development. Through this research, we can gain a deeper appreciation of the ecological, cultural, and scientific significance of karst landscapes and develop strategies for their long-term protection and management.

The current research on geosite potential of karsts is unique in comparison to previous studies on almost similar titles or field of study in several aspects. The study "Karst Geoheritage and Geotourism Potential in The Pek River Lower Basin (Eastern Serbia)" aimed to assess the geoheritage and geotourism potential of the karst landscape in the Pek River Lower Basin in Eastern Serbia. The authors used a combination of fieldwork, literature review, and spatial analysis to identify and describe the geosites and geodiversity of the area, as well as to assess its tourism potential.

The study identified several geosites in the Pek River Lower Basin, including caves, sinkholes, and natural bridges, which were found to have significant geological, ecological, and cultural value. The authors also noted the presence of several endemic plant species and rare bird species in the area.

Based on the assessment of the geosites and their potential for tourism, the authors proposed several geotourism routes, which would allow visitors to explore the geological and cultural heritage of the area. They also highlighted the need for sustainable tourism development, which considers the conservation and protection of the area's natural and cultural resources.

Overall, the study provides a comprehensive assessment of the geoheritage and geotourism potential of the karst landscape in the Pek River Lower Basin and proposes strategies for sustainable tourism development. It contributes to the broader field of geotourism and geodiversity conservation, highlighting the importance of promoting the cultural, scientific, and ecological value of karst landscapes (Antić et al., 2019).

Overview of the study which entitled as "A Modified Geosite Assessment Model (M-GAM) And Its Application on The Lazar Canyon Area (Serbia)" aimed to develop a modified geosite assessment model (M-GAM) and apply it to the Lazar Canyon area in Serbia. The authors used a combination of fieldwork, literature review, and statistical analysis to identify and assess the geosites of the area, as well as to test the validity and reliability of the M-GAM.

The study found that the M-GAM was a useful tool for assessing the geosite potential of the Lazar Canyon area, and that it was effective in identifying the most significant geosites in the area. The authors also noted the importance of considering both the scientific and cultural value of geosites in the assessment process.

Based on the assessment, the authors proposed several geotourism routes, which would allow visitors to explore the geological and cultural heritage of the area. They also highlighted the need for sustainable tourism development, which considering the conservation and protection of the area's natural and cultural resources.

Overall, the study provides a useful framework for assessing the geosite potential of karst landscapes and proposes strategies for sustainable tourism development. It contributes to the broader field of geotourism and geodiversity conservation, highlighting the importance of promoting the cultural, scientific, and ecological value of geosites (Tomić & Božić, 2014).

The study which entitled as "Geoheritage as The Basis for Geotourism Development: A Case Study in Jeli District, Kelantan, Malaysia" aimed to identify and assess the geosites and geoheritage potential of the Jeli district in Kelantan, Malaysia, and to propose strategies for sustainable geotourism development.

The authors used a combination of fieldwork, literature review, and statistical analysis to identify and assess the geosites of the area, as well as to determine the geoheritage potential of the district. The study found that the Jeli district has a significant geological heritage, including limestone formations, caves, and waterfalls, which have significant scientific, educational, and cultural value.

Based on the assessment, the authors proposed several geotourism routes, which would allow visitors to explore the geological and cultural heritage of the area. They also highlighted the need for sustainable tourism development, which takes into account the conservation and protection of the area's natural and cultural resources, as well as the involvement of local communities in the planning and development process.

Overall, the study provides a valuable framework for assessing the geoheritage potential of karst landscapes and proposes strategies for sustainable tourism development. It contributes to the broader field of geotourism and geodiversity conservation, highlighting the importance of promoting the cultural, scientific, and ecological value of geosites, and the need to involve local communities in the planning and development process (Adriansyah et al., 2015).

These three studies of Karst Geoheritage and Geotourism Potential in the Pek River Lower Basin (Eastern Serbia), A Modified Geosite Assessment Model (M-GAM) and Its Application on The Lazar Canyon Area (Serbia), and Geoheritage as The Basis for Geotourism Development: A Case Study in Jeli District, Kelantan, Malaysia, are all focus on geotourism development and the evaluation of geosites' potential for tourism.

This study on the geosite potential of karsts offers a unique contribution to the existing literature on the subject. Compared to previous studies with similar titles or field of study, this research stands out due to its innovative methods and comprehensive analysis. The first study investigates the geotourism potential of the Karst Geoheritage and Geotourism Potential In The Pek River Lower Basin in Eastern Serbia, highlighting the area's karst landscape and geological heritage. The study identifies several significant geosites, such as caves, sinkholes, and waterfalls, and proposes several geotourism routes to showcase the area's natural and cultural heritage (Antić et al., 2019).

The second study proposes a modified geosite assessment model, which incorporates local stakeholders' perspectives in evaluating the significance of geosites in the Lazar Canyon area of Serbia. The model is used to identify the most important geosites in the area and to propose strategies for sustainable geotourism development (Tomić & Božić, 2014).

The third study assesses the geoheritage potential of the Jeli district in Kelantan, Malaysia, and proposes geotourism routes to showcase the area's geological and cultural heritage. The study emphasizes the importance of involving local communities in the planning and development process and prioritizing the conservation and protection of the area's natural and cultural resources.

In this research, the use of a modified geosite assessment model (M-GAM) to evaluate the geosite potential of six caves in the study area, while the previous studies also used geosite assessment models to evaluate the geotourism potential of specific areas, the M-GAM used in this study was specifically modified to account for the unique features of karst landscapes and caves.

Furthermore, this study represents the first investigation of geosite potential of karsts in the study area, making it a unique contribution to the understanding of karst geomorphology in the region. Although similar studies have been conducted on geosite potential in other karst areas, the specific characteristics of this study area have not been explored in depth until now.

In summary, the use of the M-GAM in this study, and its application to the evaluation of caves in the karst landscape, represents a valuable contribution to the field of geotourism research, and provides a more comprehensive and detailed understanding of the geosite potential of karst caves.

The study on the "M-GAM Method in Function of Tourism Potential Assessment: Case Study of The Sokobanja Basin In Eastern Serbia" is a prominent publication in the field of geosite assessment and geotourism development that cannot be neglected or omitted. This study explores the use of a geosite assessment model, the M-GAM method which can be applied to karst landscapes to identify and evaluate their potential for geotourism development. This methodology is relevant to research on the geosite potential of karsts because it allows for a comprehensive evaluation of the potential of karst landscapes as geosites.

By drawing on the insights and findings of the " M-GAM Method in Function of Tourism Potential Assessment: Case Study of The Sokobanja Basin in Eastern Serbia", more comprehensive understanding of the potential for karst landscapes as geosites, as well as the strategies that can be used to promote geotourism in these areas can be developed. Acknowledging the significance of this publication in the field of geosite assessment and geotourism development also demonstrates the rigor and depth of the research on the geosite potential of karsts.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

The introduction of a research study on the geology and geosite potential of karsts in Kampung Batu Udang, Dabong District, Kelantan would typically provide an overview of the study area including its location, geology, and previous research conducted in the area.

3.2 Materials/Equipment

In a research study on the geology and geosite potential of karsts in Kampung Batu Udang, Dabong District Kelantan, the following materials and equipment's were used includes:

Materials:

Geologic maps: Various types of geologic maps, such as geological, geomorphological, and structural maps, were used to understand the geology and geomorphology of the study area.

a. Aerial photographs: Aerial photographs were used to identify the location of karst features, such as sinkholes and caves, and to study the geomorphology of the area.

b. Field notebooks and cameras: Field notebooks and cameras were used to record observations and to document fieldwork.
c. Samples: Rock samples were for petrographic analysis.

Equipment:

a. GPS: A GPS device are used to accurately locate and map karst features, such as sinkholes and caves, and to measure the elevation of these features.
b. Compass: A compass is used to measure the strike and dip of rock layers and to study the structural geology of the area.
c. Hammer: A hammer is used to collect rock samples for petrographic analysis.
d. GIS software: GIS software is used to analyse the data and create maps of the study area.

3.3 Methodology

The methodology section of a thesis outlines the steps taken to conduct the research and provides a detailed explanation of the research methods used. This section should describe the research design, data collection, and analysis procedures used in the study.

3.3.1 Preliminary Studies

A preliminary study is an initial research effort that is conducted to gather information and identify potential research questions before the main study is conducted. In the research study entitled "Geology and Geosite Potential of Karsts in

Kampung Batu Udang, Dabong District Kelantan," a preliminary study would involve gathering information about the geology, geomorphology, and previous research conducted in the study area, as well as identifying potential research questions and objectives for the main study.

A literature review would be conducted to gather information about the geology, geomorphology, and previous research conducted in the study area. This would involve researching scientific journals, government reports, and other publications to gather information about the karst features in the study area and the geotourism potential. Other than that, the reconnaissance survey would be conducted to identify the location and distribution of karst features in the study area. This would involve visiting the study area and identifying potential karst features, such as sinkholes, caves, and karst hills.

3.3.2 Field Studies

Field study is an essential aspect of the research study entitled "Geology and Geosite Potential of Karsts in Kampung Batu Udang, Dabong District Kelantan." The field study would involve collecting data and samples in the field, to study the geology and geomorphology of the karst features in the study area, as well as to identify the highest geosite potential areas according to the M-GAM value.

The following is a possible outline of the field study:

i. Field mapping: Field mapping was conducted to identify the location and distribution of karst features in the study area. The field mapping would involve visiting the study area and recording the location and characteristics of different karst features, such as sinkholes, caves, and karst hills, using GPS and mapping software.

ii. Geomorphological analysis: Geomorphological analysis was conducted to analyse the geomorphological characteristics of the karst features, such as visiting the karst features, observing, and taking data of their geomorphological characteristics.

iii. Sampling: Samples was collected from karst features for petrographic analysis in the laboratory.

iv. Laboratory Analysis: Laboratory analysis was conducted to identify the minerals in the rocks sample of the karst rocks. This would involve collecting rock samples from the karst features and analysing them by examining thin section under optical microscope to observe the characteristics of mineral such as colour, shape, grain size, sorting and relief.

3.3.3 Laboratory Work

Laboratory analysis is a crucial aspect of the data collection and analysis process. The laboratory analysis methods used in this study would include the petrographic analysis.

Petrographic analysis is a technique used to study the mineralogy and texture of rock samples. In the research study, the petrographic analysis would be used to identify the rock types present in the study area and to understand the processes that formed the karst features by examining the thin section of rock samples under a microscope to identify the mineralogy and texture of the rock samples that present in the study area (McLemore et al.).

Specifically, the following steps would be taken in the petrographic analysis:

1. Sample collection: Rock samples was collected from different karst features in the study area, such as sinkholes, caves, and karst hills. The samples were collected in a way that would represent the different rock types and formations in the study area.
2. Sample preparation: The rock samples was prepared for analysis by cutting them into thin sections. The thin sections would be then polished and coated with a thin layer of metal (typically gold or silver) to make them conductive.
3. Mineral identification: The thin sections was examined under a microscope to identify the minerals present in the rock samples. This was done by observing the optical properties of the minerals, such as their colour, refractive index, and pleochroism.
4. Texture analysis: The texture of the rock samples was analysed to identify the arrangement of the minerals in the rock. This was done by observing the size, shape, and orientation of the mineral grains.
5. Rock identification: Based on the mineralogy and texture of the rock samples, the rock types present in the study area was identified. This would involve comparing the samples with known rock types and using petrographic reference books and databases.

3.3.4 Data Processing

In the research study entitled "Geology and Geosite Potential of Karsts in Kampung Batu Udang, Dabong District Kelantan" that employs the M-GAM method, data collection would involve a combination of field mapping, geomorphological analysis, petrographic analysis, and a questionnaire survey.

Field mapping would be conducted to identify the location and distribution of karst features in the study area. The field mapping would involve visiting the study area and recording the location and characteristics of different karst features, such as sinkholes, caves, and karst hills, using GPS and mapping software.

Geomorphological analysis would be conducted to analyse the geomorphological characteristics of the karst features, such as their shape, size, and distribution. This would involve visiting the karst features and taking data of their geomorphological characteristics.

Petrographic analysis would be conducted to identify the minerals characteristics of the karst rocks. This would involve collecting rock samples from the karst features and analysing them.

In addition to the field mapping, geomorphological analysis and petrographic analysis, a questionnaire survey would also be an important aspect of data collection in the research study. The questionnaire survey would be used to gather information from the experts, local residents and visitors about their perceptions and attitudes towards the karst features in the study area and their potential for geotourism development (Sax et al., 2003).

Steps of producing and collecting the data of questionnaire survey:

1. Questionnaire design: The questionnaire would be designed to collect information about the participants' demographics, their knowledge, and perceptions of the karst features in the study area, and their attitudes towards geotourism development in

the area. The questionnaire would include both open-ended and closed-ended questions and would be pre-tested to ensure its validity and reliability.

2. Sampling: A sample of local residents and visitors would be selected to participate in the questionnaire survey. The sample would be selected to be representative of the population of interest and would include experts, residents and visitors of different ages, genders, and education levels.
3. Data collection: The questionnaire survey would be conducted in person or over the phone. The participants would be asked to answer the questions in the questionnaire, and their answers would be recorded.
4. Data analysis: The data collected from the questionnaire survey would be analysed using statistical software to identify patterns and trends in the participants' perceptions and attitudes towards the karst features and geotourism development in the study area.
5. Conclusion: The results of the questionnaire survey would be used to supplement.

3.3.5 Data Analysis and Interpretation

The M-GAM method, or the Modified Geosite Assessment Model, is a method used to evaluate the geosite potential of karst areas. The M-GAM method is useful for identifying the most suitable karst features for geotourism development, by evaluating the geomorphological characteristics of karst features.

The following is a detailed explanation of the methodology used in a research study that employs the M-GAM method:

i. Study Area Selection: The study area is selected based on the presence of karst features and the potential for geotourism development. In this study, the study area was Kampung Batu Udang, Dabong District, Kelantan Malaysia, which has a high concentration of karst features, including caves.

ii. Data Collection: Data was collected through field mapping, geomorphological analysis, and petrographic analysis. The field mapping was conducted to identify the location and distribution of karst features in the study area. The geomorphological analysis was conducted to analyse the geomorphological characteristics of the karst features, including their shape, size, and distribution. The petrographic analysis was conducted to identify the minerals characteristics of the karst rocks.

iii. Data Preparation: Collected data is prepared for analysis by editing and standardizing it. The data was checked for errors, inconsistencies, and outliers, and any errors were corrected. The data was then standardized to a common format, and missing data was filled in with estimates.

iv. Data Analysis: The data was analysed using GIS software to create maps of the study area, and to identify the high geosite potential areas. The GIS analysis was used to identify the areas with the highest concentration of karst features and to evaluate the geomorphological and the characteristics of these features.

v. Geosite potential assessment: The geomorphological and the characteristics of the karst features were evaluated, and a geosite potential index was calculated for each feature. This index was based on geomorphological characteristics that are considered important for geotourism development.

vi. Recommendations for geotourism development: Based on the geosite potential assessment, the recommendations for geotourism development were made, including the location and development of the visitor centres. The recommendations were made in a way that maximizes the geosite potential of the area.

vii. Validation: The results of the study were validated using a set of independently collected data. The validation step is important to ensure that the results of the study are reliable and can be used to make decisions about the geotourism development of the area.

The Modified Geosite Assessment Model (M-GAM) consists of two key indicators: Main Values (MV) and Additional Values (AV). The MV indicators are divided into 12 categories and the AV indicators are divided into 15 categories. Each of these indicators is marked from 0 to 1, with 0 indicating the lowest potential and 1 indicating the highest potential (Bratić et al., 2020). Refer Table 5.4 and 5.5.

Table 3.1: Structure of M-GAM model values (Marija Bratić et.al., 2020).

Main values (MV)	
Scientific/educational value (VSE)	
Rarity	Number of closest identical sites
Representativeness	Didactic and exemplary characteristics of the site due to its own quality and general configuration
Knowledge on geoscientific issues	Number of written papers in acknowledged journals, thesis, presentations, and other publications
Level of interpretation	Level of interpretive possibilities on geological and geomorphologic processes, phenomena and shapes and level of scientific knowledge
Scenic/aesthetic (VSA)	
Viewpoints	Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site.
Surface	Whole surface of the site. Each site is considered in quantitative relation to other sites
Surrounding landscape and nature	Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban area, etc.
Environmental fitting of sites	Level of contrast to the nature, contrast of colors, appearance of shapes, etc.
Protection (VPr)	
Current condition	Current state of geosite
Protection level	Protection by local or regional groups, national government, international organizations, etc.
Vulnerability	Vulnerability level of geosite
Suitable number of visitors	Proposed number of visitors on the site at the same time, according to the surface area, vulnerability, and current state of Geosite
Additional values (AVs)	
Functional values (VFns)	
Accessibility	Possibilities of approaching to the site
Additional natural values	Number of additional natural values in the radius of 5 km (geosites also included)
Additional anthropogenic values	Number of additional anthropogenic values in the radius of 5 km
Vicinity of emissive centers	Closeness of emissive centers
Vicinity of important road	Closeness of important road networks in the in radius of 20 km

Table 3.1: *Cont…*

network	
Additional functional values	Parking lots, gas stations, mechanics, etc.
Touristic values (VTr)	
Promotion	Level and number of promotional resources
Organized visits	Annual number of organized visits to the geosite
Vicinity of visitor's centers	Closeness of visitor center to the geosite
Interpretative panels	Interpretative characteristics of text and graphics, material quality, size, fitting to surroundings, etc.
Number of visitors	Annual number of visitors
Tourism infrastructure	Level of additional infrastructure for tourist (pedestrian pathways, resting places, garbage cans, toilets, etc.)
Tour guide service	If exists, expertise level, knowledge of foreign language(s), interpretative skills, etc.
Hostelry services	Hostelry service close to geosite
Restaurant service	Restaurant service close to geosite

Table 3.2: Grade used in M-GAM model.

Grades (0.00-1.00)	0.00	0.25	0.50	0.75	1
1.Rarity	Common	Regional	National	International	The only occurrence
2.Representativeness	None	Low	Moderate	High	Utmost
3.Knowledge on geoscientific issues	None	Local publications	Regional publications	National publications	International publications
4. Level of interpretation	None	Moderate level of processes but hard to explain to non-experts	Good example of processes but hard to explain to nonexperts	Moderate level of processes but easy to explain to common visitor	Good example of processes and easy to explain to common visitor
5. Viewpoints	None	1	2 to 3	4 to 6	More than 6
6.Surface	Small	—	Medium	—	Large
7. Surrounding landscape and nature	—	Low	Medium	High	Utmost
8. Environmental fitting of sites	Unfitting	—	Neutral	—	Fitting
9.Current condition	Totally damaged (as a result of human activities)	Highly damaged (as a result of natural processes)	Medium damaged (with essential geomorphologic features preserved)	Slightly damaged	No damage

Table 3.2: *Cont…*

Grades (0.00-1.00)	0.00	0.25	0.50	0.75	1
10. Protection level	None	Local	Regional	National	International
11. Vulnerability	Irreversible (with possibility of total loss)	High (could be easily damaged)	Medium (could be damaged by natural processes or human activities)	Low (could be damaged only by human activities)	None
12. Suitable number of visitors	0	0–10	10–20	20–50	More than 50
13. Accessibility	Inaccessible	Low (on foot with special equipment and expert guide tours)	Medium (by bicycle and other means of man-powered transport)	High (by car)	Utmost (by bus)
14. Additional natural values	None	1	2–3	4–6	More than 6
15. Additional anthropogenic values	None	1	2–3	4–6	More than 6
16. Vicinity of emissive centres	More than 100 km	100–50 km	50–25 km	25–5 km	Less than 5 km
17. Vicinity of important road network	None	Local	Regional	National	International

Table 3.2: *Cont…*

Grades (0.00-1.00)	0.00	0.25	0.50	0.75	1
18. Additional functional values	None	Low	Medium	High	Utmost
19. Promotion	None	Local	Regional	National	International
20. Organized visits	None	Less than 12 per year	12–24 per year	24–48 per year	More than 48 per year
21. Vicinity of visitor's centres	More than 50 km	50–20 km	20–5 km	5–1 km	Less than 1 km
22. Interpretative panels	None	Low quality	Medium quality	High quality	Utmost quality
23. Number of visitors	None	Low (less than 5,000)	Medium (5,001–10,000)	High (10,001–100,000)	Utmost (more than 100,000)
24. Tourism infrastructure	None	Low	Medium	High	Utmost
25. Tour guide service	None	Low	Medium	High	Utmost
26. Hostelry service	More than 50 km	25–50 km	10–25 km	5–10 km	Less than 5 km
27. Restaurant service	More than 25 km	10–25 km	10–5 km	1–5 km	Less than 1 km

To calculate the M-GAM value, the values for each group of indicators consists of several sub indicators are combined using a mathematical formula, which would weight the different indices according to the importance of the characteristics for the geosite potential. The resulting M-GAM value would be a number between 0 and 1, with higher values indicating higher geosite potential (Bratić et al., 2020).

As M-GAM have two key indicators which is Main Values (MV) and Additional Values (AV), the AV are divided into 12 to 15 sub-indicators which will be mark from value 0 to 1 (Bratić et al., 2020).

According to new research (Bratić et al., 2020) value of sub indicator M-GAM model need to be sum following to the M-GAM equation. Im will give more accurate in objective and obtaining the final results. Where Iv_k is referring to the visitor rating or value for each sub-indicator. Whereas K is the total number of visitors. Value for Im parameter are between any value from 0.00 to 1.00 (Bratić et al., 2020).

In M-GAM equation, the Im value is implied for each sub indicators separately rated by the visitors. Then, the Im value will be multiplied separately with the value rated by the experts. The results will come out as a matrix of MV which will be plot at x-axis and AV at y-axis. Then the matrix will be divided into 9 fields which are Z (i, j), (i, j = 1, 2, 3) (Bratić et al., 2020). Below is the define of Im and M-GAM equation (Bratić et al., 2020).

$$\mathrm{Im} = \frac{\sum_{k=1}^{k} \mathrm{Iv}_k}{K}$$

$$M - GAM = MV + AV$$

$$AV = \sum_{i=1}^{n} Im_i^* MV_i$$

$$AV = \sum_{i=1}^{n} Im_j^* AV_j$$

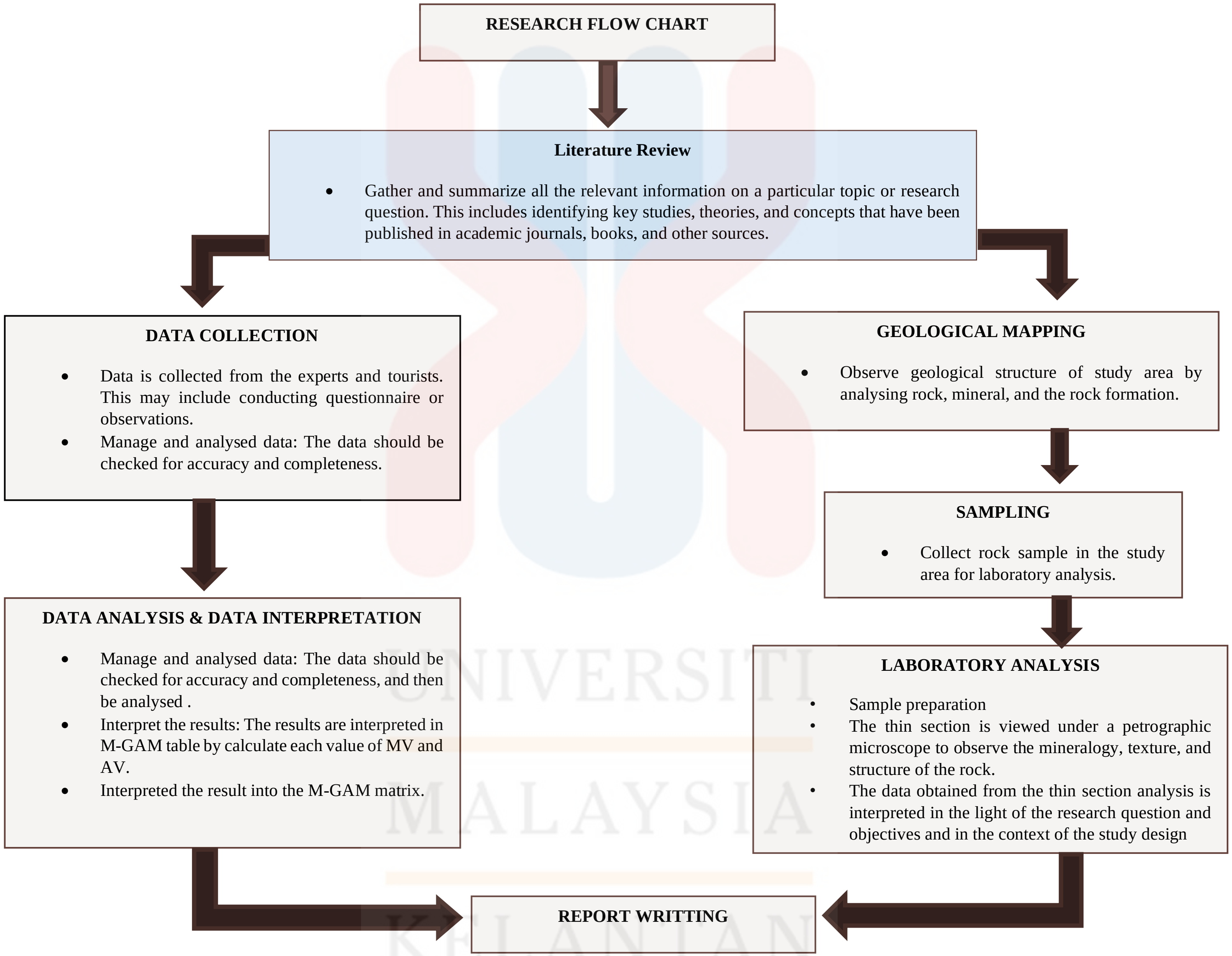


Figure 3.1: Research flow chart.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is a broad field of study that encompasses the study of the Earth's physical structure, composition, and processes.

4.1.1 Geology

General geology in this section is describing the general information about the study area as well as discussing it in more detailed on its geomorphology, structural geology, lithostratigraphy, and historical geology. The details were primarily addressed by general geology of interpretation of secondary data obtained from the previous research study and data collection.

The information and findings were obtained from the previous research study, and some are from a few geology agencies and more. The data then was processed and then represented it by producing its respective maps. For the overall geology setting, it was displayed in geological map with the scale of 1:25, 000. The geological map was given the information of rock boundaries, cross section, distribution of rock units and the age of every rock unit in the study area. Thus, this chapter are becoming one of the most important chapter.

In geomorphology, it focusses on the study of landform and its process that related to origin and evolution. Through the studying of geomorphology, the mechanism which contributed to the earth changes can be understanding. Whereas for stratigraphy, it is studying in rock strata analysis, its families and the age following with their strata relationships. Meanwhile for lithostratigraphy, in this research it was used to classify the association between the strata. The structural geology are studying about the structure of earth and rock geometries as both were related in explaining the history of deformation. All of these field is important in interpreting the historical events. Geomorphology, stratigraphy, and structural geology knowledge were combined as to expose the past geological event (Oldroyd & Grapes, 2008).

4.1.2 Accessibility

The research is conducted at Kampung Batu Udang at Dabong district in the region of Kelantan, Malaysia. There are two main roads that connects Jeli and Dabong which is the route at KM37 Jalan Jeli-Dabong near Kg Reka and KM34 Jalan Jeli-Dabong near the Kuala Balah Road Transport Department. The study area can be reached from Jeli by using both main roads stated above. With the assistance of a good availability, the area of research can be entered.

Figure 4.1: Road at KM37 Jalan Jeli-Dabong near Kg Reka.

Figure 4.2: Road at KM34 Jalan Jeli-Dabong near the Kuala Balah.

Kuala Balah is a town located in the state of Kelantan in the Jeli district. It got its name in conjunction with its location located at the confluence of two rivers, namely Sungai Pergau and Sungai Balah. This town is located approximately 32 km from the main center of the Jeli which is Bandar Jeli. It is also located 20 km from the town of Dabong, Kuala Krai, 145 km from Kota Bharu, 100 km from Kuala Krai via Jeli-Dabong-Sungai Sam-Kuala Krai Road and 85 km from Gua Musang city center via Jeli-Jelawang-Gua Musang Road.

It is a town located in the middle of Jalan Persekutuan 66 which connects Bandar Jeli and Dabong in Kuala Krai district, Kelantan. Jalan Persekutuan 66 is an alternative route from Gua Musang to Kota Bharu other than the Kuala Krai-Gua Musang Highway (Jalan Persekutuan 8). Since this Town is often a stopover for users who use the Jalan Persekutuan 66, there is a R&R area in the Kuala Balah Town which provided for the convenience of road users.

4.1.3 Settlement

Population distribution and settlement patterns can play an important role in the research study entitled "Geology and Geosite Potential of Karsts in Kampung Batu Udang, Dabong District, Kelantan." The population density, settlement patterns, and land use in the study area can have an impact on the geosite potential of the karst features.

For example, high population density and urbanization in the study area can lead to increased anthropogenic impact on the karst features, such as pollution and damage to the natural resources. This can negatively impact the geosite potential of the karst features (Sunkar et al.).

On the other hand, a low population density and dispersed settlement patterns can lead to reduced anthropogenic impact on the karst features, which can positively impact the geosite potential of the karst features (Sunkar et al.).

Table 4.1: Population distribution and settlement in Dabong, 2020.

District	**Dabong**	
Population	Male	**50.9%**
	Female	**49.1%**
	Citizen	**95.2%**
	Non-citizen	**4.8%**

	Total	17.4 Thousand
Population Density	**1 031km^2**	
Household	**3.8 Thousand**	
Average Household Size	**4.6 Thousand**	
Place of Residence	**4.9 Thousand**	

Source: (Department of Statistics Malaysia Official Portal, n.d)

4.1.4 Forestry

Forestry can play an important role in the Dabong district of Kelantan, as it is a major land use in the region. The forests in Dabong are primarily composed of tropical lowland forests and are home to a wide range of plant and animal species. They also play a vital role in regulating the local climate and hydrology, as well as providing a range of ecosystem services such as carbon sequestration, soil conservation, and water regulation.

Agricultural land use is the dominant land use in Dabong district of Kelantan, as it is a major economic activity in the region. The district is known for its paddy fields, rubber and oil palm plantations, and cash crops such as pepper, banana, and durian. Agriculture is the main source of income for many of the local communities, and it is likely that the majority of the land in the district is used for agriculture.

In terms of the research study "Geology and Geosite Potential of Karsts in Kampung Batu Udang, Dabong District, Kelantan", forestry can have both positive and negative impacts on the geosite potential of the karst features in the area. On one hand, well-managed forests can provide a buffer against human impact on the karst features, which can positively impact the geosite potential. They can also provide important habitats for a wide range of wildlife and plant species, which can contribute to the uniqueness and scenic beauty of the karst features.

On the other hand, poorly managed or over-exploited forests can lead to increased soil erosion and sedimentation, which can negatively impact the geomorphology and hydrology of the karst features, and thus negatively impact the geosite potential. They can also lead to increased human impact on the karst features through increased access or increased pollution from logging or mining activities.

It is important to consider the management and conservation of the agricultural resources in the study area and how it could affect the geosite potential of the karst features. For example, sustainable agricultural practices such as agroforestry, crop rotation, and integrated pest management can reduce the negative impacts of agricultural land use on the karst features while preserving the local economy.

4.1.5 Traverses and Observations

Traverses and observations are key components of many geological research studies. A traverse is a line or path along which geological features are observed and recorded, typically in the field. Observations made during a traverse can include features such as rock outcrops, sedimentary structures, and other geological structures and features. The data collected during a traverse is then used to create geological maps, cross-sections, and other geological models. These models are important for understanding the geology of an area and for identifying potential geosites for conservation or geotourism. Overall, traverses and observations are essential for conducting high-quality geological research and for gaining a deeper understanding of the earth's geology.

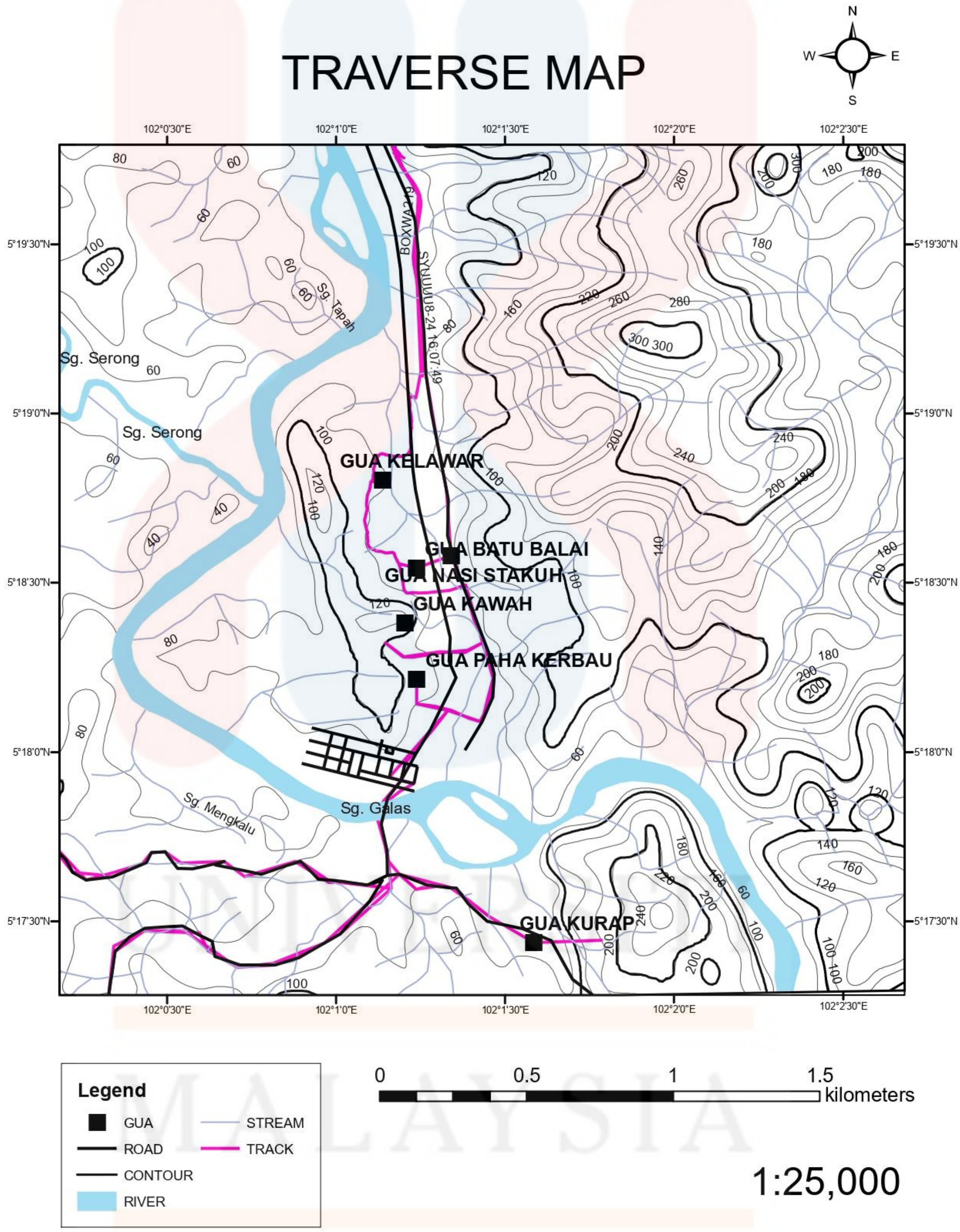


Figure 4.3: Traverse map of Dabong.

4.2 Geomorphology

The study area is located in the Dabong district of Kelantan, Malaysia, which is characterized by a tropical climate and a complex geology. The karst features in the study area are formed by the dissolution of limestone and dolomite rocks, which are common in this region.

The geography of the study area plays a role in the formation and distribution of the karst features, as well as in the geomorphology and geology of the area. For example, the elevation, slope, and any aspect of the karst features are characteristics that influenced by the geography of the area. Similarly, the shape, size, and distribution of the karst features are geomorphological characteristics that are also influenced by the geography of the area.

Additionally, the study area is situated near the river, which is a major watercourse that has a significant impact on the hydrology and geomorphology of the karst features in the area. The hydrology of the area can affect the formation and preservation of the karst features, as well as the distribution of flora and fauna in the area.

Furthermore, the geography of the study area is also important in terms of accessibility, infrastructure, and services, which are factors that influence the geotourism potential of the karst features. The location of the study area, as well as its proximity to major transportation routes, would affect the ease of access to the karst features, which can impact the geotourism potential of the area (Sunkar et al., 2022).

4.2.1 Geomorphologic Classification

In general, morphography means a description of the shape of the earth's surface. It can be divided into hills/ridges, mountains or volcanoes, valleys, and plains. Several other approaches to geomorphological mapping apart from morphography are ridge patterns, drainage patterns and slope shapes.

The techniques used to assess the study area were by field observation, from topography map analysis and through the satellite imagery. Based on Van Zuldam classifications (1986), the geomorphology of the study area was classified in the Table 4.1 below based on its elevation of contour.

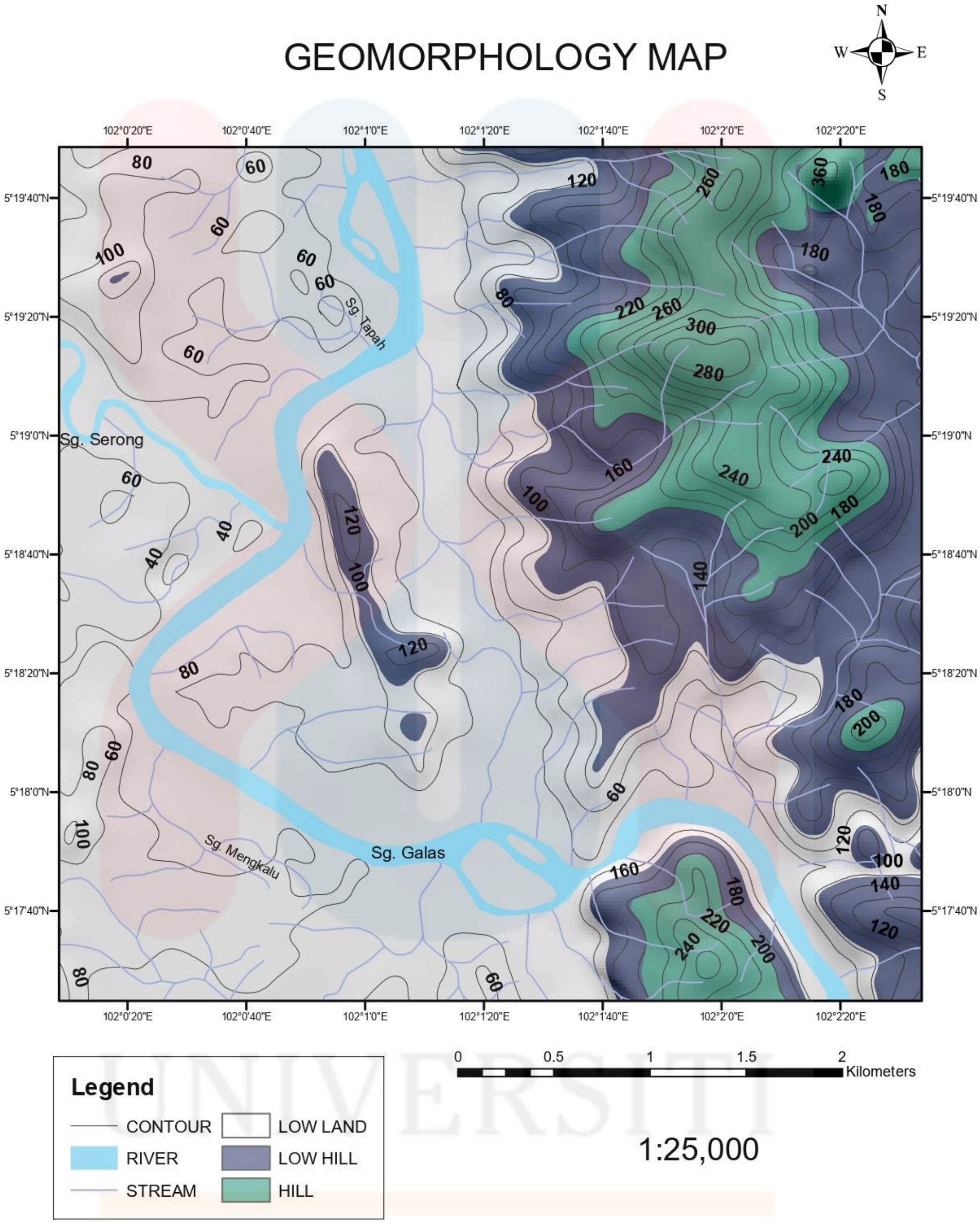


Figure 4.4: Geomorphology map of Dabong.

Table 4.2: Classification of morphography of the study area based on elevation.

Elevation	Morphography
50 metres - 100 metres	Low land
100 metres - 200 metres	Low hill
200 metres- 500 metres	Hill

4.2.2 Weathering

Karst features, such as caves, are formed through the process of chemical weathering in limestone or other soluble rocks. This process is known as karstification. Rainwater, which is naturally slightly acidic, dissolves the calcium carbonate in the limestone, creating a network of interconnected channels and cavities. Over time, this creates larger openings, such as caves (*Karst*, n.d.).

There are several factors that can influence the rate and intensity of karstification, including climate, geology, hydrology, and biota. For example, in areas with high rainfall and warm temperatures, karstification can occur more rapidly due to increased water flow and more intense chemical reactions. In contrast, in areas with low rainfall and cooler temperatures, the process may be slower (*Karst*, n.d.).

In addition to chemical weathering, physical weathering also plays a role in the formation of karst features. This can occur through processes such as freeze-thaw cycles, erosion, and dissolution. Over time, the combination of chemical and physical weathering can create a variety of unique and complex karst features (*Karst*, n.d.).

Understanding the weathering processes that contribute to the formation of karst features is important for effective conservation and management of these geosites. By studying the geological characteristics of karst areas, a better understanding can be gained regarding the factors that contribute to the formation of caves and other karst features.

4.2.3 Drainage Pattern

Erosion and tectonic activities that produce valley forms as a place for water to flow, will then form certain patterns which are referred to as flow patterns. This flow pattern is closely related to the type of rock, the geological structure of the erosion conditions and the history of the earth's formation. The drainage system that develops on the surface of the earth is regionally controlled by the slope, type and thickness of rock layers, geological structure, type and density of vegetation and climatic conditions.

Drainage patterns are easily recognized from topographic maps or aerial photographs, especially on a large scale. Small erosional branches and branches on the surface of the earth will be clearly visible, while on a medium scale they will show an overall pattern as a reflection of rock type, geological structure, and erosion. The drainage pattern in layered rocks depends on the type, distribution, thickness, and area of the rock layers as well as structural geology such as faults, joints, direction, and shape of folds. Figure 4.4 was showing the drainage map of Dabong (Ray, 1960).

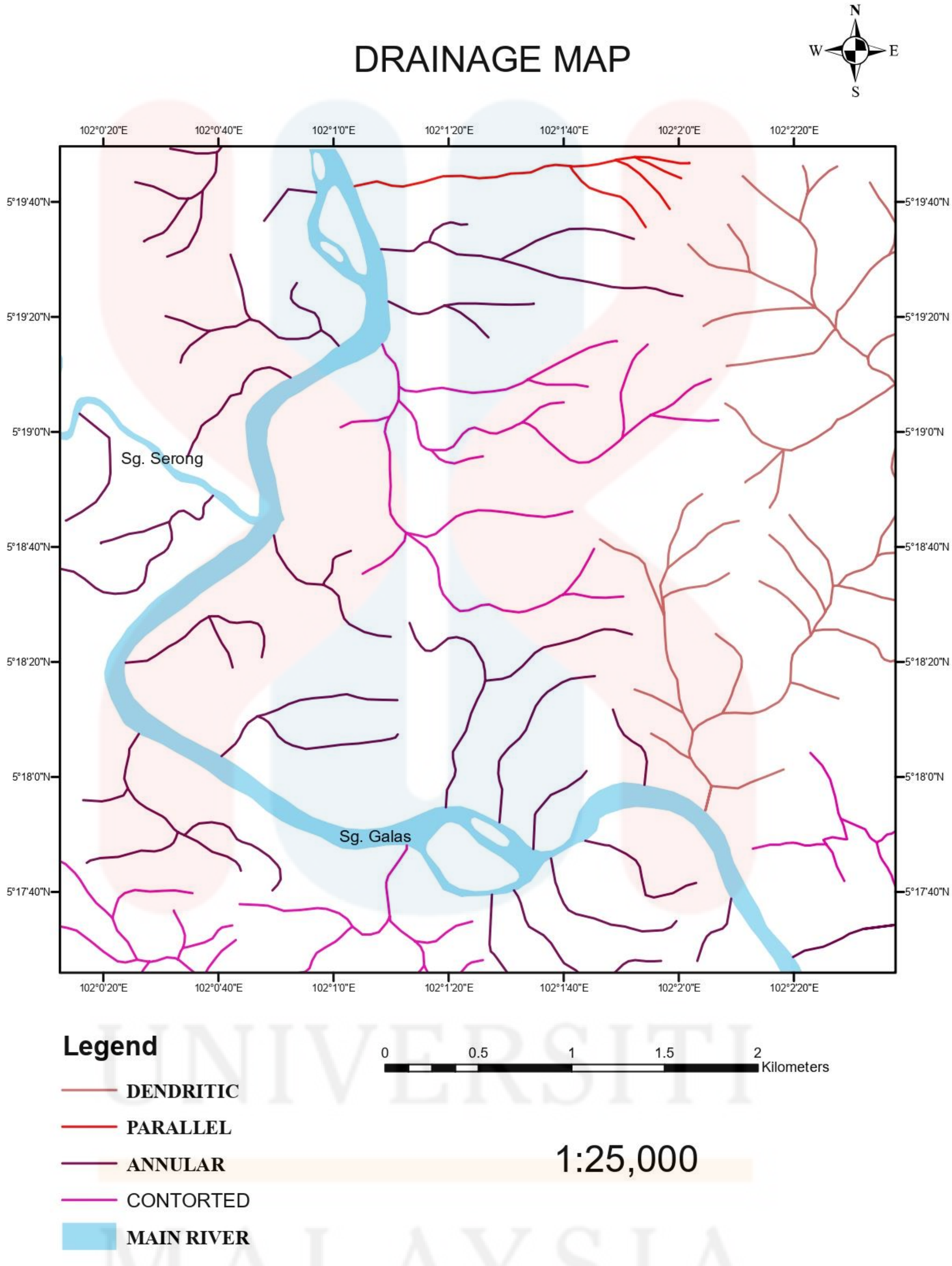


Figure 4.5: Drainage map of Dabong.

Table 4.3: Flow patterns and their characteristics.

BASIC FLOWING PATTERNS	CHARACTERISTICS
DENDRITIC	Sedimentary rock layers are relatively flat or crystalline rock packages are not uniform and have resistance to weathering. Regionally the watershed has a gentle slope, the type of drainage pattern forms spreading branches like shady trees.
PARALLEL	In general, it shows areas with moderate to rather steep slopes and can also be found in elongated hilly landform areas. There is often a transitional pattern between the dendritic pattern and the parallel or trellis pattern. The elongated landform of the hills with a parallel drainage pattern reflects that the hills are affected by folding.
ANULAR	Dome/cone structures, basins and possible hacks (stocks)
CONTORTED	Develop from the disruption of a pre-existing drainage pattern. The patterns described above are accordant or correlated with the structure and relief over which they flow. Those streams that are discordant with the rocks over which they flow are either antecedent or superimposed. For instance, antecedent streams flowed across bedrock structures prior to uplift. Slow mountain building permitted stream erosion to keep pace with uplift.

Source: (Van Zuldam classifications, 1986)

Based on the table above, the drainage map which had been produced by using ArcMap was showing dendritic, parallel, annular, and contorted patterns.

4.3 Lithostratigraphy

In the study area, there consists of two lithology which are quartzite and marble. Table 4.3 shows the stratigraphic sequence of the Gua Musang Formation.

Table 4.4: The stratigraphic sequence of Gua Musang.

Time	Lithology
Middle Triassic	Limestone, along with shale and volcanic rocks
Early Triassic	Argillitic limestone, shale and volcanic rocks
Late Permian	Shale and slate
Middle Permian	Limestone with a little shale

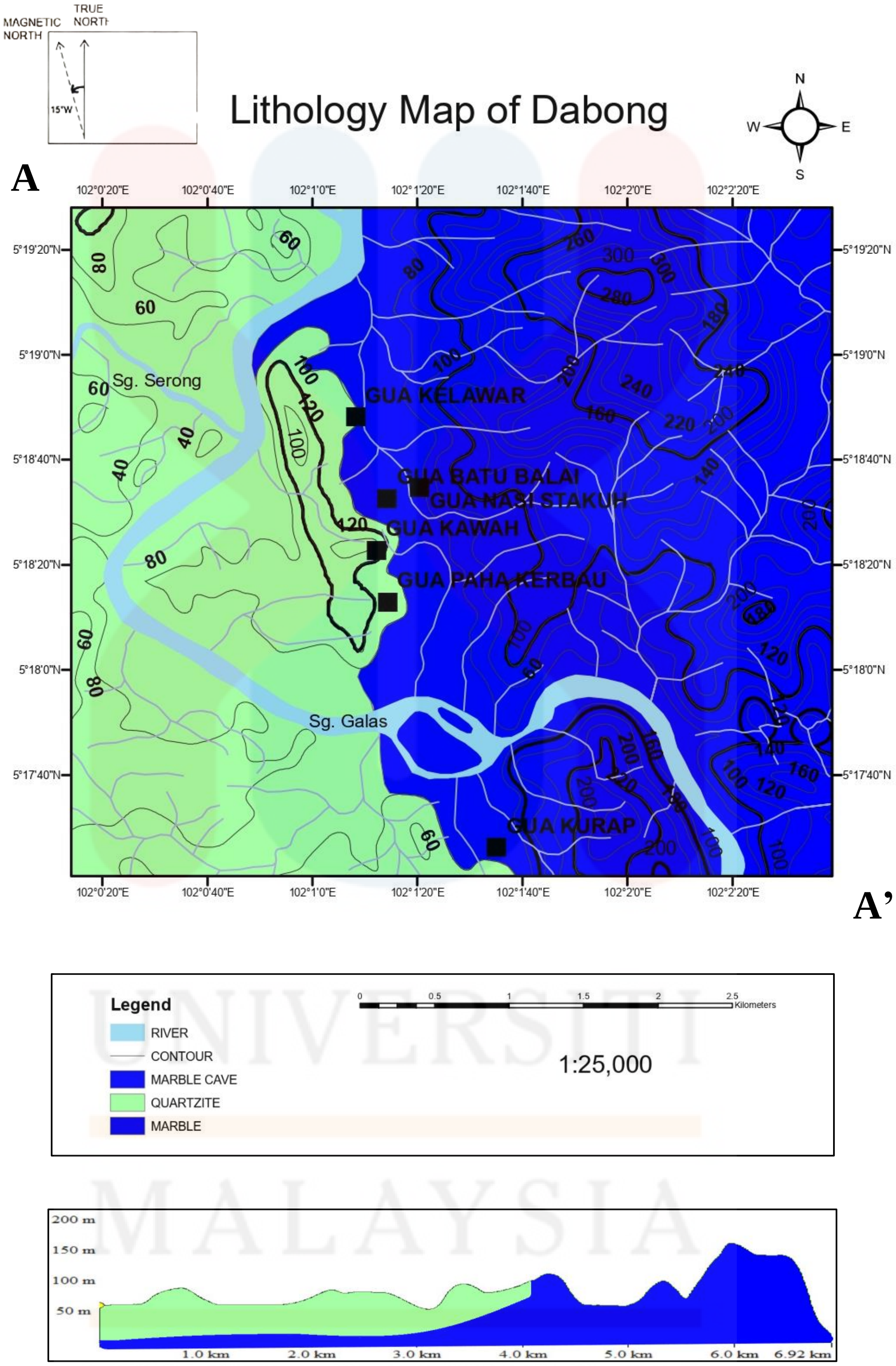
Source: (Mohamed et al., 2016)

Based on the interpretation on secondary data and previous research, the research area is consisting of two types of lithology which are marble and quartzite. The marble rock was formed during Permian period, whereas for the quartzite, it was formed during the Triassic period. Following to its formation period, it shows that the marble rock is the oldest rocks had formed compared to quartzite (Hutchison et al.). Refer to the Table 4.4 and Figure 4.5 below.

4.3.1 Stratigraphic Position

Table 4.5: Stratigraphic Column.

LITHOLOGY	DESCRIPTION	UNIT	PERIOD	ERA
	Most of the marble rock have a thin layer of calcite intruded inside the rock layer.	**MARBLE**	**PERMIAN**	**PALEOZOIC**
	Younger age rock of quartzite forming mostly in low land (low contour).	**QUARTZITE**	**TRIASSIC**	**MESOZOIC**



A **Figure 4.6:** Geological Map of Kampung Batu Udang, A’

Dabong District, Kelantan.

4.3.2 Unit Explanation

a) Marble Unit

Limestone is a sedimentary rock containing calcium carbonate ($CaCO_3$) commonly in the form of calcite mineral. It was deposited during Permian to Middle Triassic period. The limestone unit in the study area is one of the extensively distributed of Gua Musang Group (Mohamed et al., 2016). The boundary of limestone unit is determined due to the existence of a karst morphology.

In hand specimen, marble is typically a medium to coarse-grained rock with a uniform, granular texture. Marble is composed of recrystallized carbonate minerals. The individual mineral grains are generally too small to see without a hand lens. The colour of marble can vary widely depending on its mineral content and impurities. Pure calcite marble of the hand specimen is typically white.

In terms of cleavage, marble typically does not have any preferred orientation of planes of weakness, unlike some other metamorphic rocks such as schist or gneiss. Marble is often associated with bands of other minerals such as quartz and mica. These can sometimes be visible in hand specimen.

Marble often exhibits a distinctive crystalline texture known as "sugary" or "saccharoidal" due to the recrystallization of the calcite grains during metamorphism. Marble can be distinguished from other white rocks such as quartzite or dolomite by its reaction to acid. Marble will fizz or effervesce when exposed to dilute hydrochloric acid, while quartzite and dolomite will not.

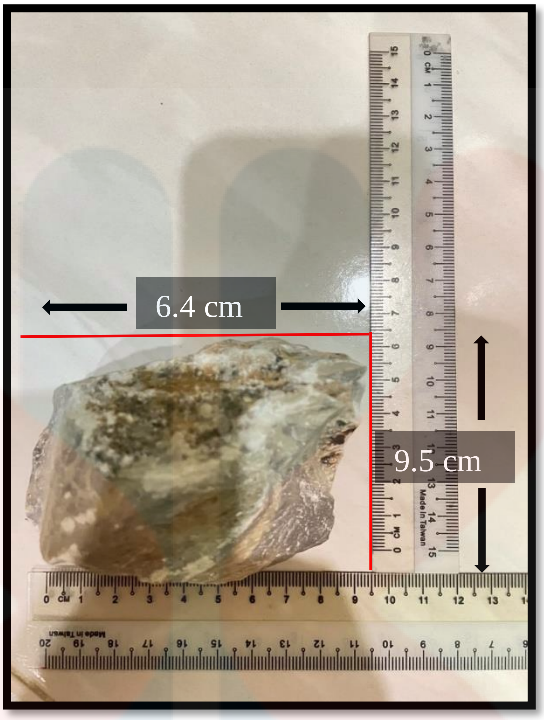


Figure 4.7: Measurement of hand specimen of marble rock.

Figure 4.8: Hand specimen of marble rock.

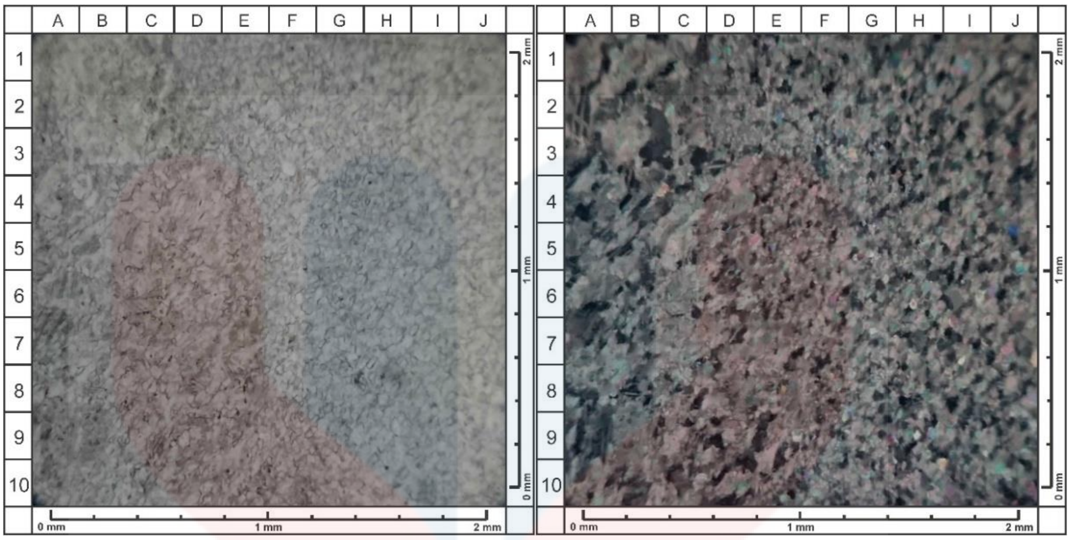


Figure 4.9: Microscopic observation under XPL and PPL view of marble unit thin section.

Table 4.6: Description for petrographic analysis for marble unit.

Microscopic Observations	Mineral Composition
The observations were carried out at 10x ocular magnification and 5x objective magnification and on the observation of non-foliated structures (granuloses), crystalloblastic textures (granoblastic) including grain sizes <1/256 – 1/5 mm, sorting well.	**Calcite (A1) – 100%** The mineral calcite (A1) in this sample has 100% abundance. In plane-polarized light (PPL), it appears colourless with low to medium relief and no pleochroism. The crystal form is anhedral, and there is no 2-way hemisphere. In cross-polarized light (XPL), the mineral exhibits a pink to green colour of interference of order 4 to order 5, with symmetrical angle of darkness and absence of twins or polysynthetic structures.

b) Quartzite Unit

Quartzite and metasandstone are predominantly light grey, white or buff-coloured, sometimes iron-stained. It is mainly composed of quartz with subordinate lithic grains and mica. The textures are commonly mosaic (granoblastic) with grain-to-grain contact and sutured grain borders. Matrix is usually made up of fine-grained, siliceous, or argillaceous material which is commonly contains sericite flake or micaceous chlorite. Lithic grain probably mudstone or argillite, occurs in black colour, rounded and sometimes amorphous form due to compaction.

Quartzite typically has a very fine-grained texture that can sometimes appear sugary or granular. It has a very hard and dense texture. The colour of quartzite can vary depending on the mineral content and impurities present in the rock. It can range from white and yellow. The hand specimen of quartzite is one of the hardest rocks commonly encountered in the field, with a Mohs hardness of 7 or higher. This means it can scratch glass and is very resistant to weathering and erosion.

As the name suggests, quartzite is primarily composed of quartz grains that have been cemented together by silica. The quartz grains are well-sorted and appear as elongated and flattened grains. The quartzite displays crossbedding, which is a layering pattern formed by the migration of sand dunes or ripples. Crossbedding can appear as diagonal or wavy lines on the rock's surface.

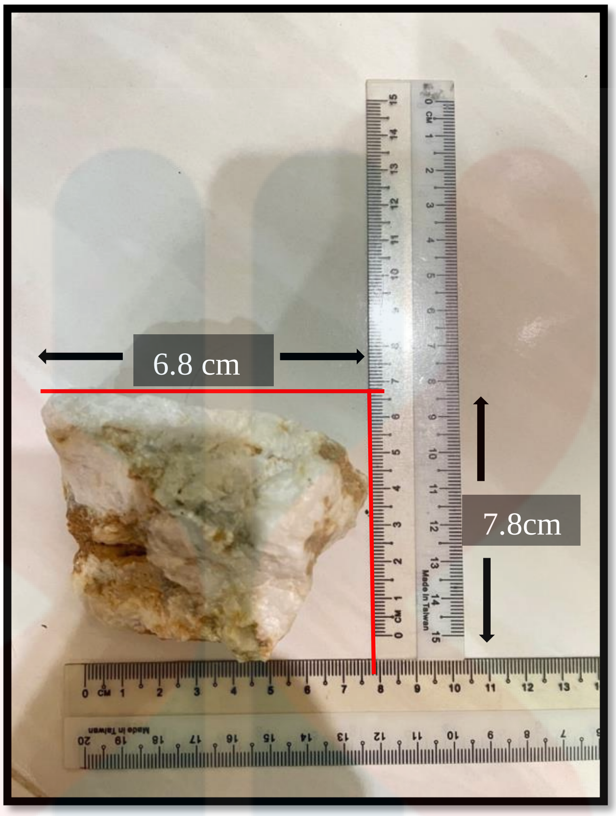


Figure 4.10: Measurement of hand specimen of quartzite rock.

Figure 4.11: Hand specimen of quartzite.

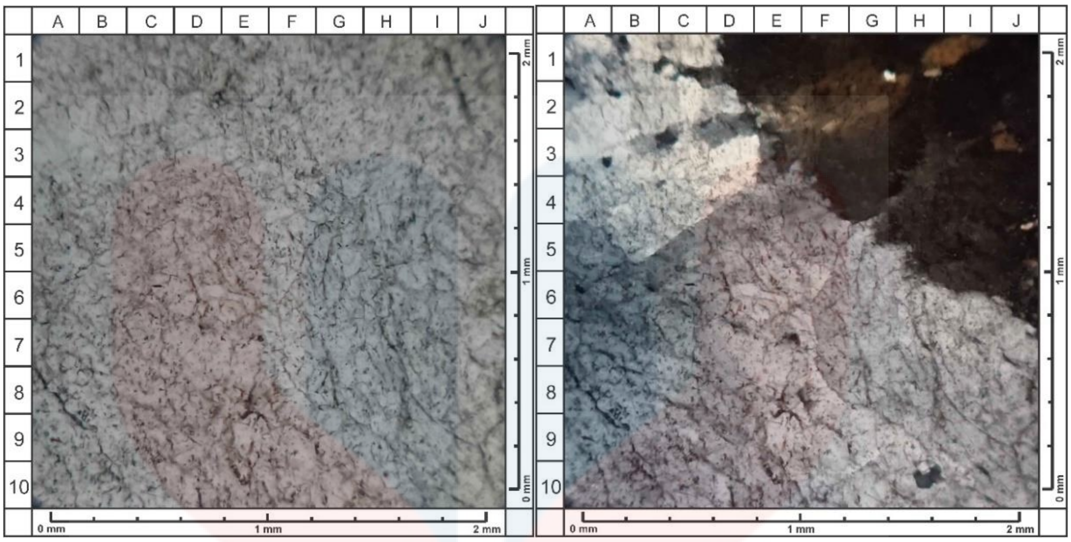


Figure 4.12: Microscopic observation under XPL and PPL view of quartzite unit thin section.

Table 4.7: Description for petrographic analysis for quartzite unit.

Microscopic Observations	Mineral Composition
The observations were carried out at 10x ocular magnification and 5x objective magnification and on the observation of non-foliated structures (granuloses), crystalloblastic (granoblastic) textures including grain sizes of >2mm, poor sorting.	**Quartz (A1) – 99%** Quartz (A1) comprises 99% of the studied sample. In PPL, the colour absorption is colourless, with low relief and absent pleochroism, and anhedral crystalline forms without hemispheres. In XPL, the colour of the gray-white interference is of the 1st order, with wavy dark corners and no twins observed. **Mineral Opaque (E8) – 1%**

	The mineral Opaque (E8) makes up 1% of the sample. In PPL, it has a black absorption colour, low relief, and pleochroism is absent with euhedral or anhedral crystalline form. In XPL, the mineral shows a black interference colour of the 1st order, and twins are absent.

4.4 Structural Geology

Structural geology is an important field of study in understanding the geosite potential of karsts. It focuses on the deformation of rocks and the processes that control their behaviour, such as jointing. These structural features are crucial in determining the shape and form of karst landscapes through the rocks and the dissolution of carbonate minerals. The study of structural geology can provide valuable insights into the geological history and processes that have shaped karst landscapes, which is essential in assessing the geosite potential. In this research study entitled "Geology and Geosite Potential of Karsts", structural geology is utilized to investigate the geological features of the karsts in the study area and their potential as geosites for conservation and management.

4.4.1 Joint

In Dabong, the karst features are formed by the dissolution of limestone rocks, the structural geology of the area play a role in the formation and distribution of these features, as well as in the geomorphology and geology of the area. The presence of joints in the limestone rocks can influence the location, size, and shape of the karst features. Figure 4.6 shows the stereonet for strike and dip data.

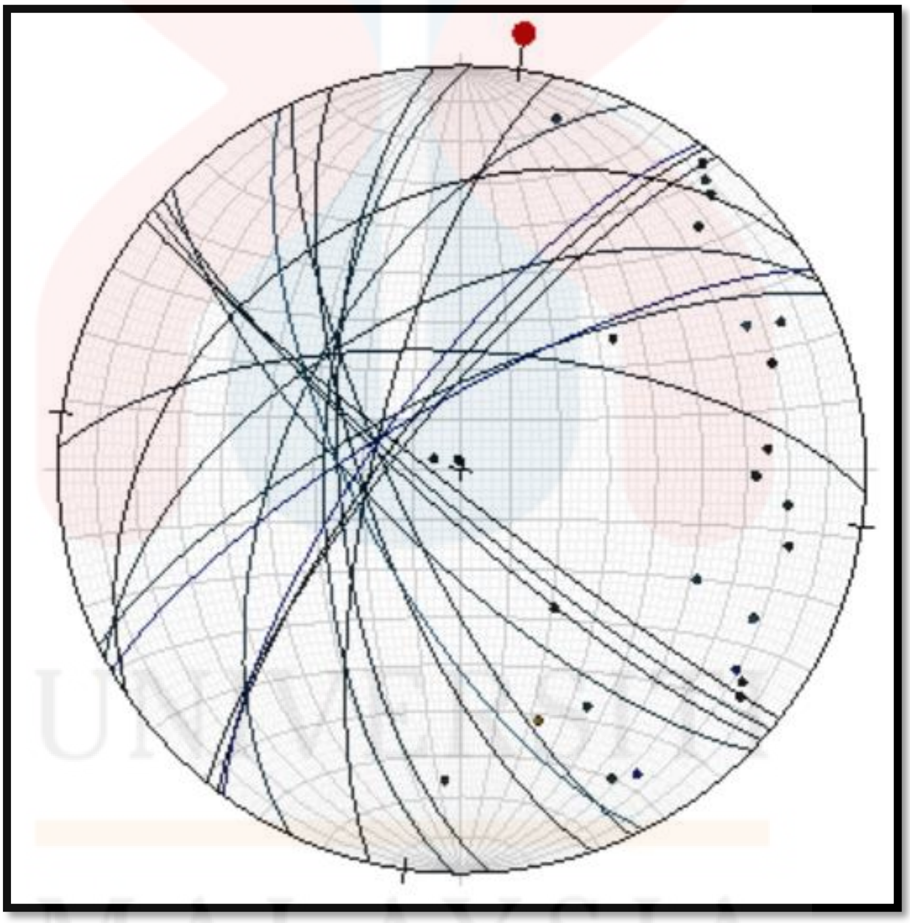


Figure 4.13: Stereonet for stike and dip data.

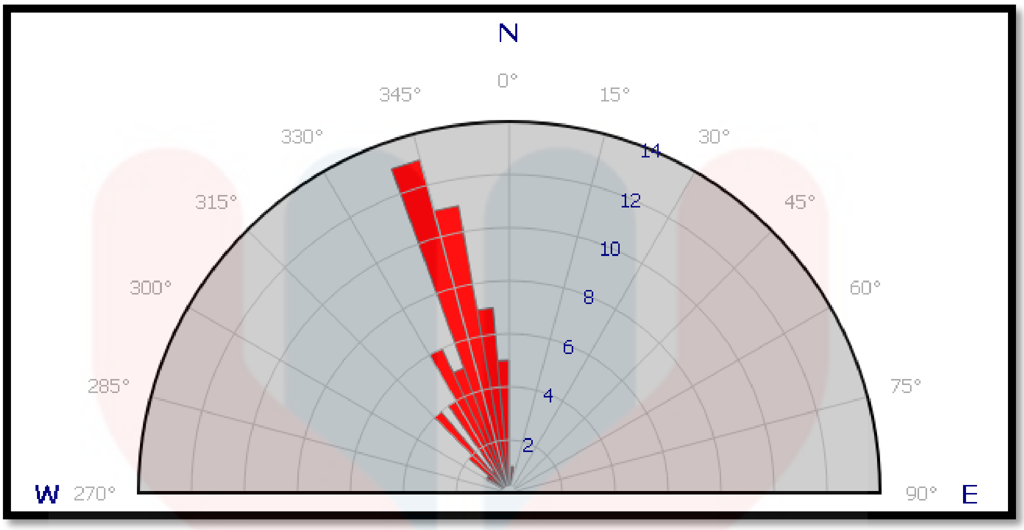
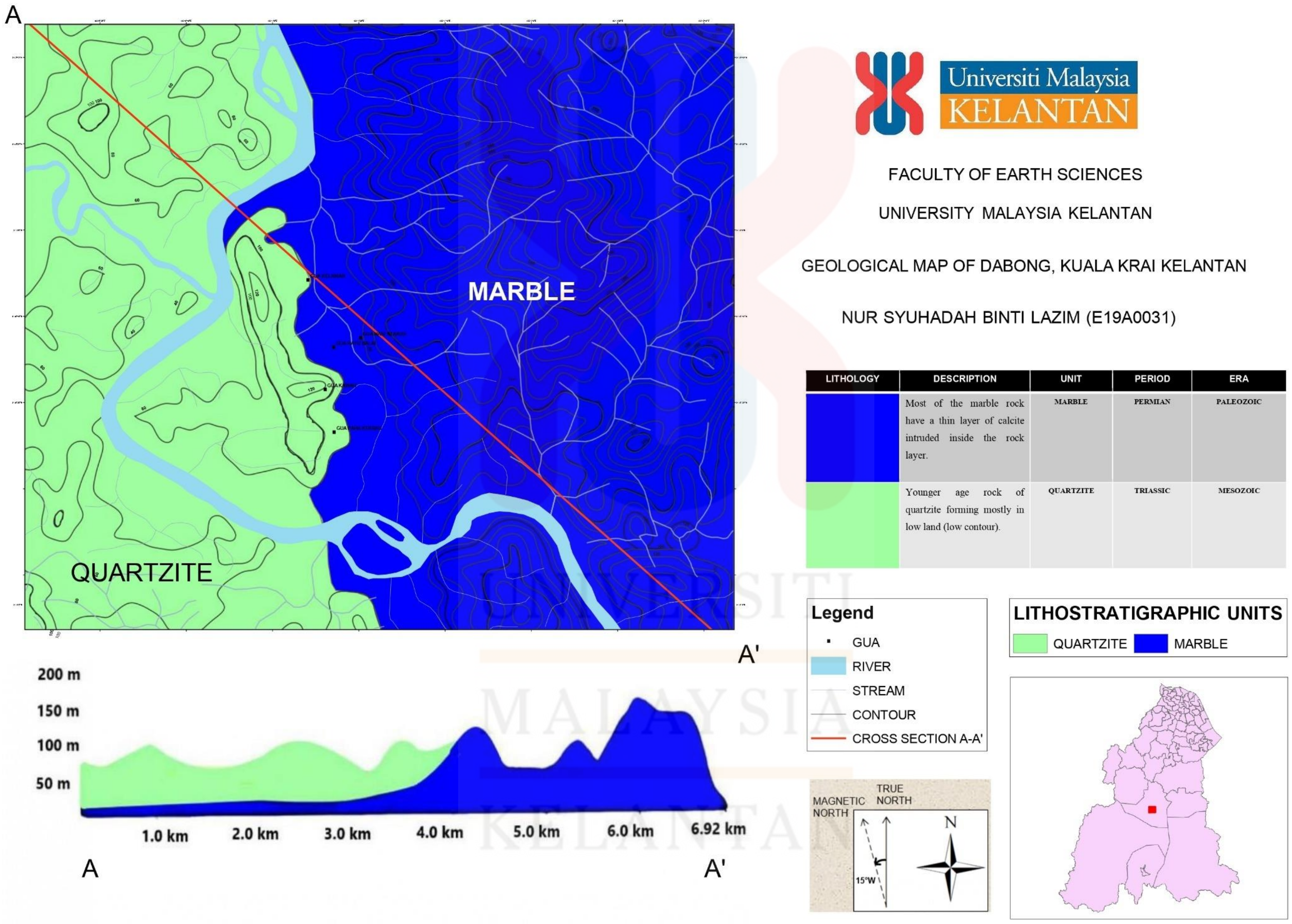


Figure 4.14: Rose diagram for joint data.

4.5 Historical Geology

Historical geology is related to the collision of Sibumasu terrain with IndoChina terrain in the Early Permian that leads to closure of Paleo-Tethys seaway. During Permian to Triassic period, the Gua Musang Formation was deposited within Central Belt in shallow marine environment which previously was the Paleo-Tethys seaway before. During Permian period, the deposited argillite rocks had created a shallow marine platform, which favorable for carbonate deposition in Permian to Triassic (Kamata et al., 2009).

The distribution of limestone in Gua Musang Formation was the result of it. Meanwhile in the Central Belt, granitoid was developed due to the Paleo-Tethys oceanic plate subduction beneath the Indochina plate during Permian to Triassic period. Result of the subduction is the forming of East Malaya volcanic arc formation. Thus, the I-type granite was produced in the volcanic arc, then the I-type granite was uplifted from beneath the surface and intruded within the lithological sequence of slate and limestone during the Late Triassic (Metcalfe, 2000).



LITHOLOGY	DESCRIPTION	UNIT	PERIOD	ERA
	Most of the marble rock have a thin layer of calcite intruded inside the rock layer.	MARBLE	PERMIAN	PALEOZOIC
	Younger age rock of quartzite forming mostly in low land (low contour).	QUARTZITE	TRIASSIC	MESOZOIC

Figure 4.15: Geological map of Dabong, Kuala Krai Kelantan.

CHAPTER 5

EVALUATION OF KARSTS IN KAMPUNG BATU UDANG, DABONG DISTRICT, KELANTAN AS GEOSITE POTENTIAL

5.1 Introduction

The evaluation of karsts in Kampung Batu Udang, Dabong District, Kelantan as a potential geosite using the M-GAM method will involve assessing the geological, geomorphological, aesthetic, and educational values of the karst features in the area. The M-GAM (Method for Geosite Assessment and Management) method is a systematic and structured approach for evaluating the potential of an area to be designated as a geosite, and for managing and conserving the site once it has been designated. The evaluation will consider the unique characteristics of the karsts in Kampung Batu Udang, such as their geomorphology, geology, and potential for educational and recreational use. The results of the evaluation will be used to determine the potential of the area to be designated as a geosite and to inform the management and conservation of the site.

5.2 Geosite Analysis for Karsts Potential based on M-GAM

M-GAM (Model-based Geostatistical Approach for Mapping) method is a geostatistical method for mapping environmental variables. It combines a spatial model of the variable of interest with data from point observations to estimate the variable's values at unsampled locations.

5.2.1 Main Values

The main value of the M-GAM method is that it allows for the estimation of the variable of interest at unsampled locations while accounting for spatial dependence and uncertainty. This can be useful in various fields, such as environmental science, natural resources management, and agriculture, where accurate estimates of environmental variables are needed for decision-making (Antić et al., 2019).

The M-GAM method also has some advantages over traditional geostatistical methods, such as kriging, it allows for the inclusion of ancillary data and the use of a variety of spatial models. This can provide more flexibility in modelling the spatial variation of the variable of interest and can lead to more accurate estimates.

It's important to note that M-GAM method is just one among many geostatistical methods, and its suitability for a particular application will depend on the specific data and research question.

a) Scientific/Educational Values (VSE)

In M-GAM method, VSE is one of the several values that can be included in the mapping process, alongside the environmental variable of interest, ancillary data, and other values such as conservation values or economic values. This allows for the mapping of the environmental variable of interest to consider multiple criteria and goals.

For example, if the environmental variable of interest is vegetation, the mapping process could include not only the vegetation type, but also the scientific or educational value of that vegetation, such as its rarity, or the presence of unique ecosystems or endangered species.

b) Scenic/Aesthetic Values

Scenic/Aesthetic values could include assessing the natural scenery, views, and the potential for recreational use of the area. The term "scenic/aesthetic values" is not typically associated with the M-GAM method specifically, as M-GAM method is a geostatistical method for mapping environmental variables and scenic/aesthetic values are a different concept.

Scenic or aesthetic values refer to the visual qualities of a landscape that are considered to be pleasing or attractive. These values can include things like natural beauty, views, and the presence of certain types of vegetation or wildlife. Scenic or aesthetic values are subject to individual perception and can vary widely among different people (Antić et al., 2019).

While M-GAM method can be used to map environmental variables like vegetation, water, or land cover that can be used as input for studies related with scenic or aesthetic values, but it is not designed specifically to map or measure scenic or aesthetic values.

In general, the assessment of scenic or aesthetic values often involves qualitative or semi-quantitative methods, such as visual assessments, surveys, or expert opinion. These methods are typically used to evaluate the visual quality of a landscape and to identify areas that are considered to be high in scenic or aesthetic value.

While M-GAM method is a quantitative method that can be used to map and estimate environmental variables, it is not typically used directly to measure or map scenic or aesthetic values.

c) Protection (VPr)

In the M-GAM method, VPr (Variable Protection) is a term used to describe the process of protecting the estimated values of the environmental variable of interest from becoming too extreme or unrealistic.

VPr is achieved by constraining the estimated values of the variable within a certain range that is based on the observed data and physical or process-based knowledge of the variable. This is done by using a probability distribution that assigns a low probability to extreme values, which helps to prevent the estimated values from deviating too far from the observed data (Antić et al., 2019).

The VPr is implemented by incorporating a probability distribution into the estimation process, typically through the use of a Bayesian framework. The probability distribution is chosen based on the characteristics of the environmental variable and the data available, and it is used to model the uncertainty in the estimates.

The use of VPr in M-GAM is important because it helps to ensure that the estimated values of the environmental variable are physically plausible and consistent with the observed data. This can improve the reliability of the estimates and the overall performance of the M-GAM method.

5.2.2 Additional Values

The M-GAM method can be used to evaluate the potential of karst formations in Kampung Batu Udang, Dabong District, Kelantan as geosite potential by incorporating additional values into the mapping process. Some additional values that could be considered in the evaluation of karsts as geosite potential include Functional Values (VFn) and Touristic Values (VTr).

Incorporating functional values into the M-GAM mapping process can help to identify karst formations that are particularly valuable in terms of their ecological and hydrological functions. This information can be used to prioritize the protection and management of these areas as geosites (Antić et al., 2019).

a) Functional Values (VFn)

When incorporating "Functional Values" (VFn) into the M-GAM mapping process, several factors can be considered. These factors can include:

- Accessibility: The ease of access to the area can be an important factor in determining its functional value. Areas that are easily accessible are more likely to be used for activities like recreation, research, or conservation management.
- Additional natural values: This can include the presence of other natural features that contribute to the ecological or hydrological functions of the area. These can include things like wetlands, rivers, or other types of vegetation that provide important habitats or ecosystem services.
- Additional anthropogenic values: This can include the presence of human-made features that contribute to the ecological or hydrological functions of the

area. These can include things like irrigation systems or dams that regulate water resources, or wind turbines that generate clean energy.

- Vicinity of emissive centres: This can include the proximity of sources of pollution, such as industrial sites or power plants. These sources can have negative impacts on the ecological or hydrological functions of the area.
- Vicinity of important road network: The proximity of the area to major roads or transportation corridors can affect its functional value. Areas that are easily accessible by road are more likely to be used for activities like recreation, research, or conservation management.

b) Touristic Values (VTr)

"Touristic Values" (VTr) refer to the potential for tourism or recreation activities associated with the environmental variable of interest. This can include things like scenic beauty, recreational opportunities, or cultural or historical sites (Antić et al., 2019).

"Touristic Values" (VTr) into the M-GAM mapping process, several factors can be considered. These factors can include:

- Promotion: the degree of promotion and awareness of the area as a tourism destination, the area with high promotion would have a higher touristic value.
- Organized visits (SIAV8): The level of organization of visits to the area, such as guided tours or interpretive programs, can be an indicator of the area's touristic value.

- Vicinity of visitor’s centres: The proximity of the area to visitor centres, museums or other interpretive facilities can affect its touristic value.
- Interpretative panels: The presence of interpretive panels or other educational materials can enhance the touristic value of the area.
- Number of visitors: The number of visitors to the area over time can be used as an indicator of its touristic value.
- Tourism infrastructure: The availability of tourism infrastructure, such as parking, restrooms, and picnic areas, can affect the touristic value of the area.
- Tour guide service: The availability of tour guide service, can enhance the touristic value of the area.
- Hostelry service: The availability of lodging and accommodation options can affect the touristic value of the area.
- Restaurant service: The availability of restaurant or food service options can affect the touristic value of the area.

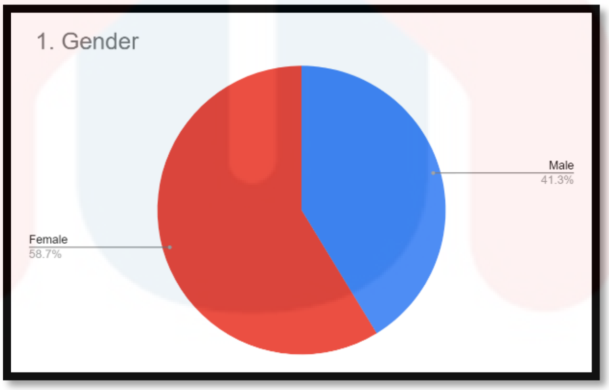
It's important to note that the inclusion of touristic values is optional, and it depends on the research question or the goal of the mapping. Also, the way to quantify these values can vary, depending on the criteria and

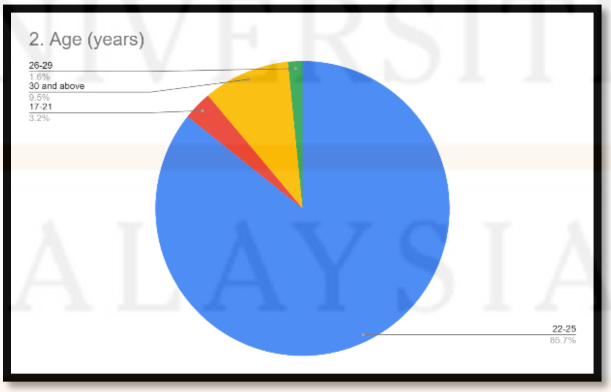
5.3 Evaluation

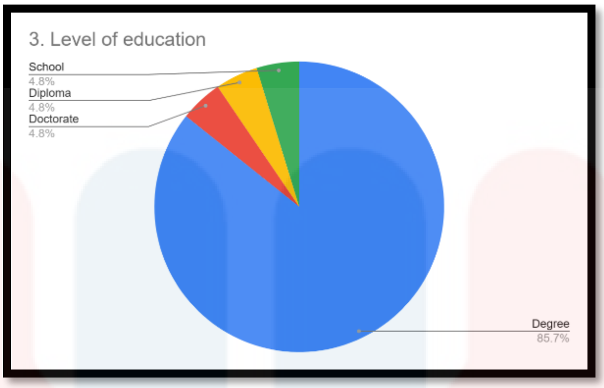
The final step is to evaluate the results of the above analyses to determine the overall potential of the karsts in Kampung Batu Udang as a geosite. This evaluation will consider the unique characteristics of the karsts, such as their geomorphology, geology, aesthetic value, and potential for educational and recreational use. Based on the results of this evaluation, a decision can be made about whether or not to designate the karsts in Kampung Batu Udang as a geosite and to develop a management plan for the area. Table 5.1 until 5.6 are shows the values assigned to each sub indicator in the M-GAM model by experts and visitors for Gua Kelawar, Gua Nasi Stakuh, Gua Batu Balai, Gua Kawah, Gua Paha Kerbau and Gua Kurap.

a) Gua Kelawar

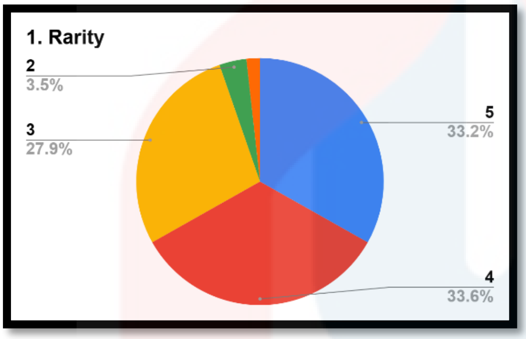
- General

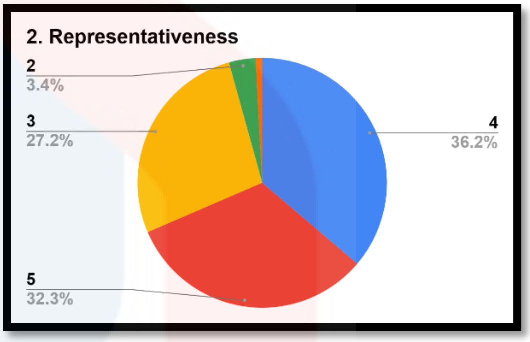


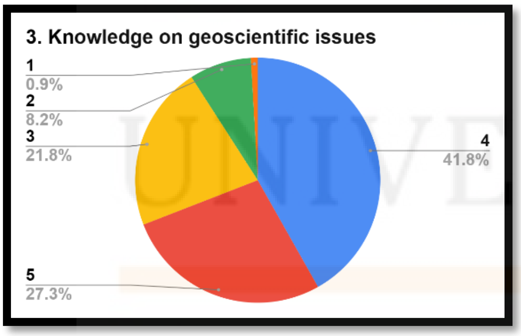


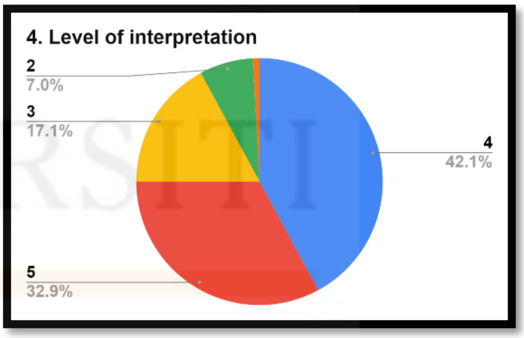

3. Level of education
School
4.8%
Diploma
4.8%
Doctorate
4.8%
Degree
85.7%

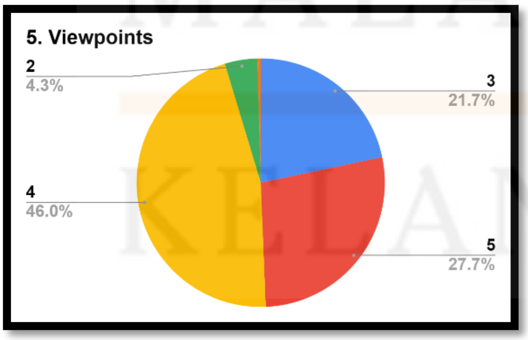
- M-GAM Value

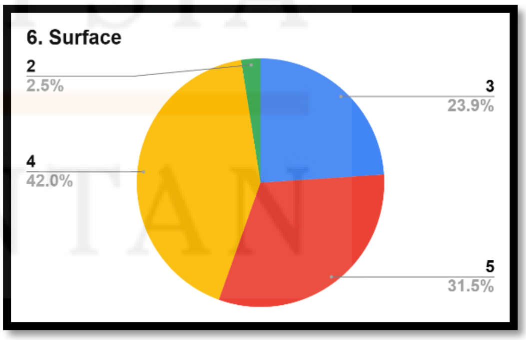

1. Rarity
2
3.5%
3
27.9%
5
33.2%
4
33.6%

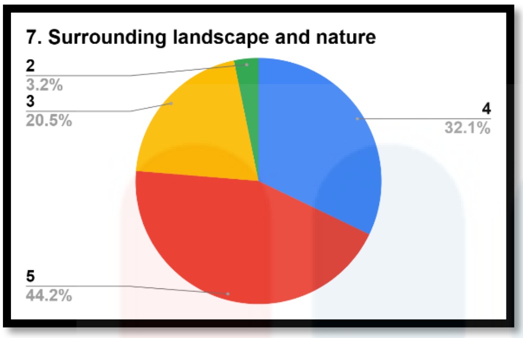

2. Representativeness
2
3.4%
3
27.2%
4
36.2%
5
32.3%

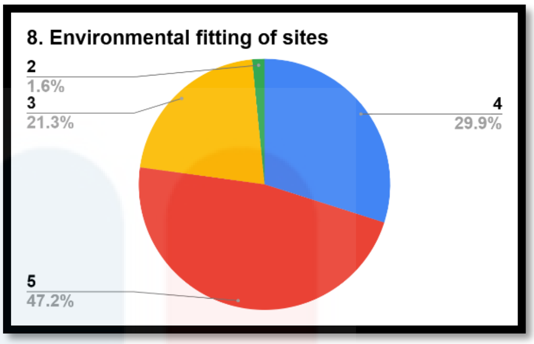

3. Knowledge on geoscientific issues
1
0.9%
2
8.2%
3
21.8%
4
41.8%
5
27.3%

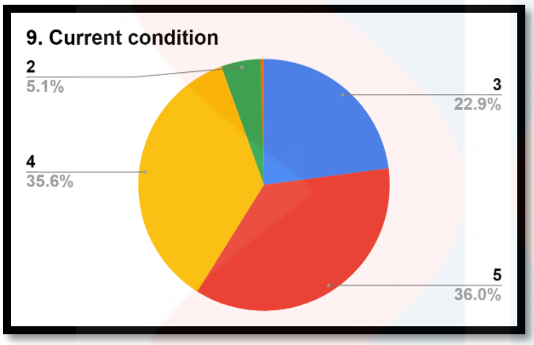

4. Level of interpretation
2
7.0%
3
17.1%
4
42.1%
5
32.9%

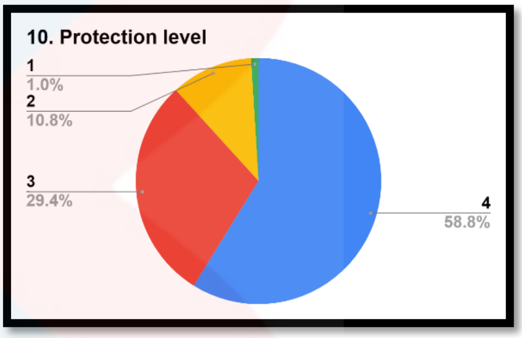

5. Viewpoints
2
4.3%
3
21.7%
4
46.0%
5
27.7%

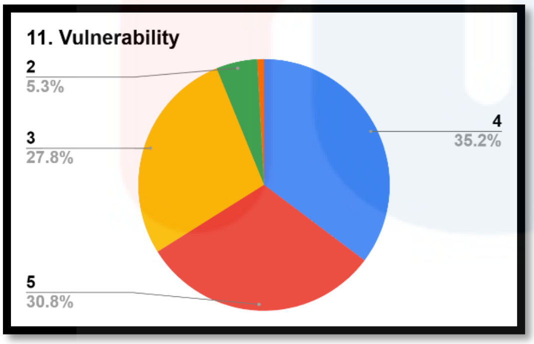

6. Surface
2
2.5%
3
23.9%
4
42.0%
5
31.5%

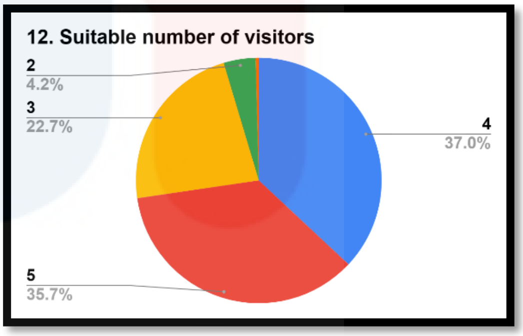

7. Surrounding landscape and nature
2
3.2%
3
20.5%
4
32.1%
5
44.2%

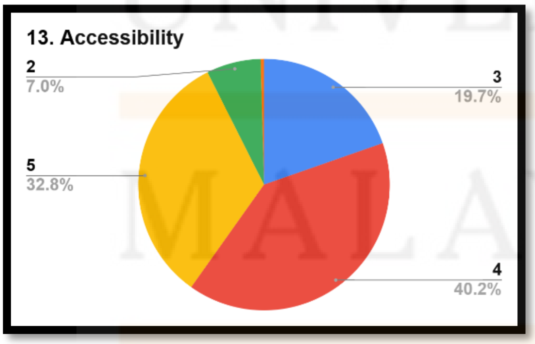

8. Environmental fitting of sites
2
1.6%
3
21.3%
4
29.9%
5
47.2%

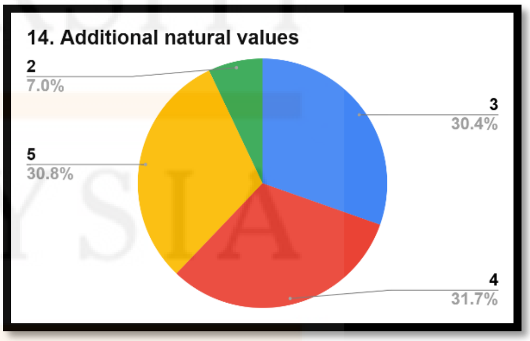

9. Current condition
2
5.1%
3
22.9%
4
35.6%
5
36.0%

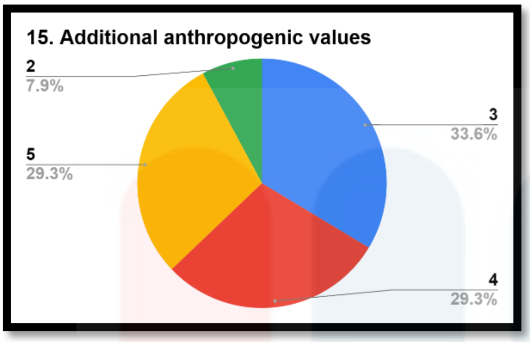

10. Protection level
1
1.0%
2
10.8%
3
29.4%
4
58.8%

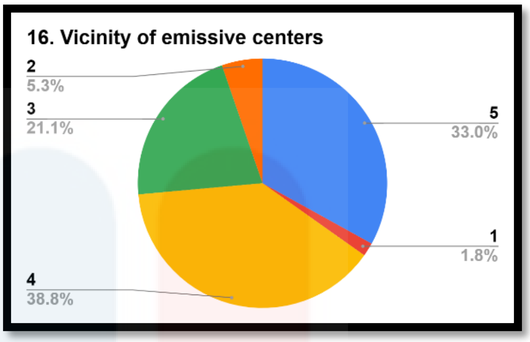

11. Vulnerability
2
5.3%
3
27.8%
4
35.2%
5
30.8%

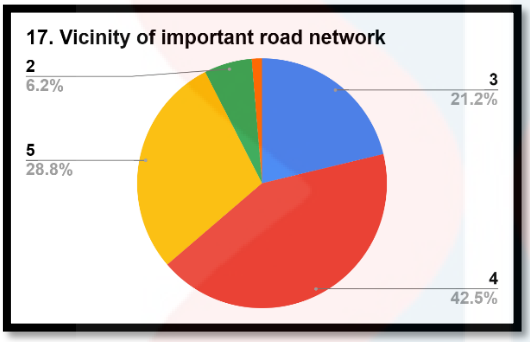

12. Suitable number of visitors
2
4.2%
3
22.7%
4
37.0%
5
35.7%

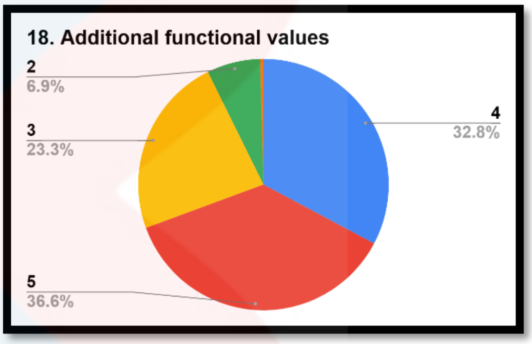

13. Accessibility
2
7.0%
3
19.7%
5
32.8%
4
40.2%

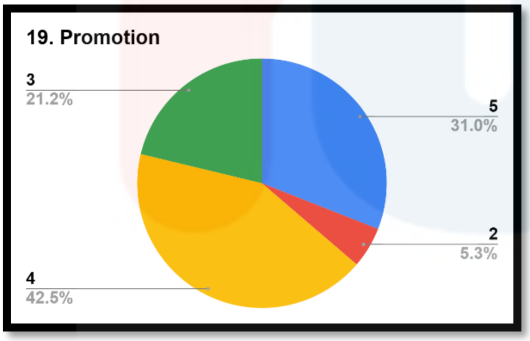

14. Additional natural values
2
7.0%
3
30.4%
5
30.8%
4
31.7%

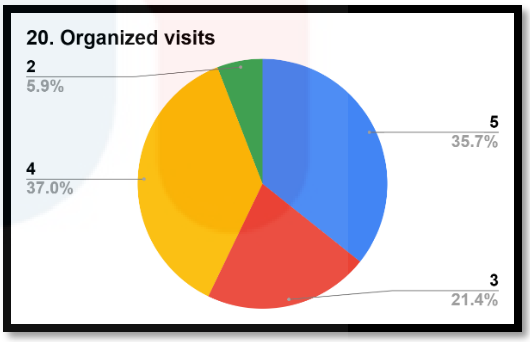

15. Additional anthropogenic values
2
7.9%
5
29.3%
3
33.6%
4
29.3%

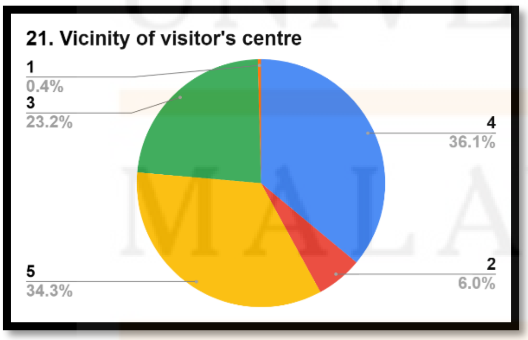

16. Vicinity of emissive centers
2
5.3%
3
21.1%
5
33.0%
1
1.8%
4
38.8%

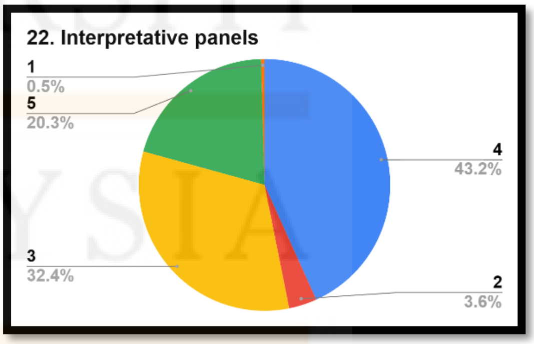

17. Vicinity of important road network
2
6.2%
5
28.8%
3
21.2%
4
42.5%

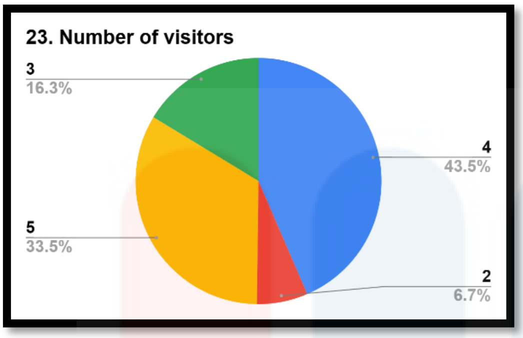

18. Additional functional values
2
6.9%
3
23.3%
4
32.8%
5
36.6%

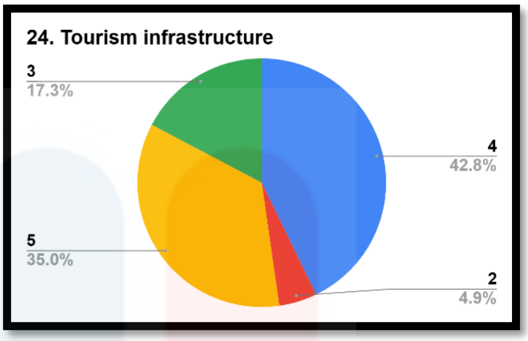

19. Promotion
3
21.2%
5
31.0%
2
5.3%
4
42.5%

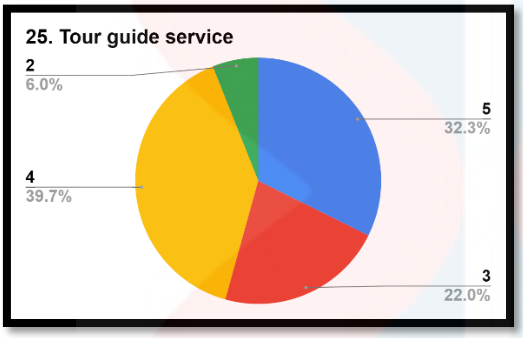

20. Organized visits
2
5.9%
4
37.0%
5
35.7%
3
21.4%

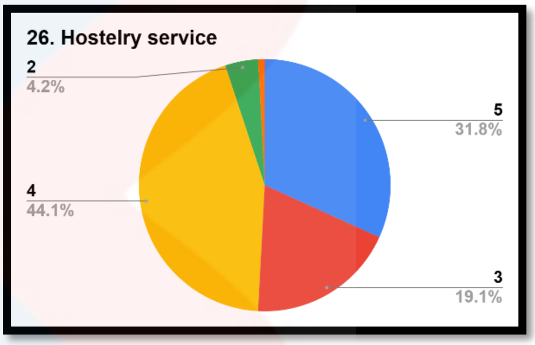

21. Vicinity of visitor's centre
1
0.4%
3
23.2%
4
36.1%
2
6.0%
5
34.3%

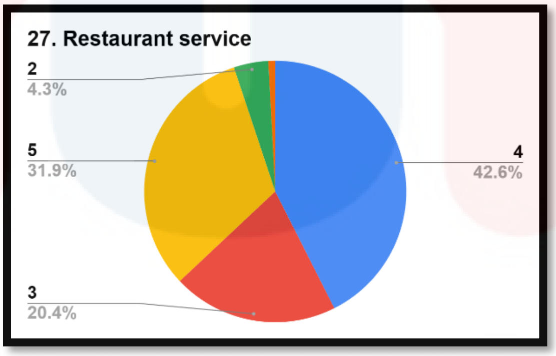

22. Interpretative panels
1
0.5%
5
20.3%
4
43.2%
3
32.4%
2
3.6%





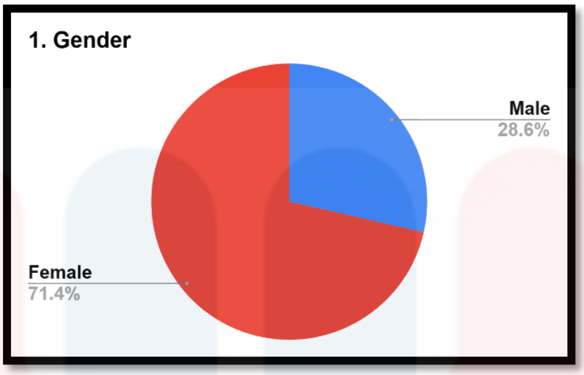


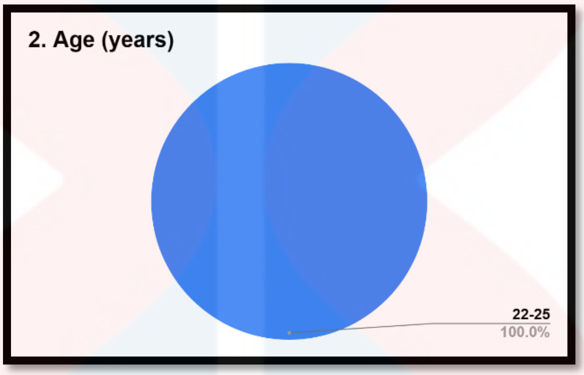


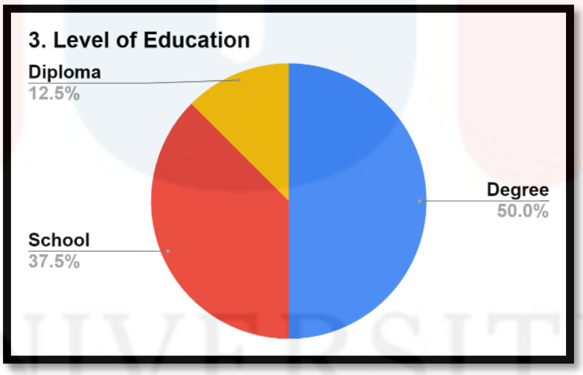


b) Gua Nasi Stakuh

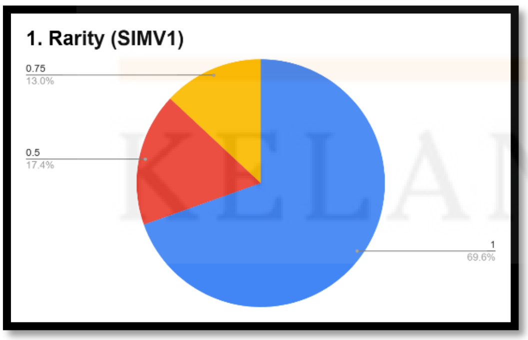
- General


1. Gender
Male
28.6%
Female
71.4%

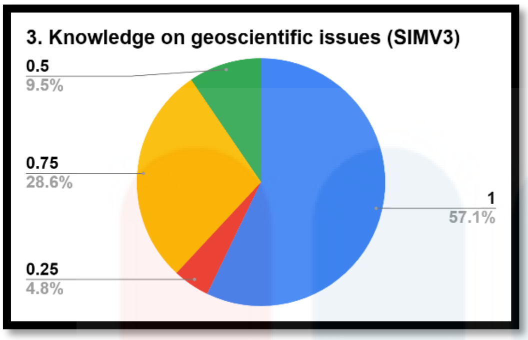

2. Age (years)
22-25
100.0%


3. Level of Education
Diploma
12.5%
Degree
50.0%
School
37.5%

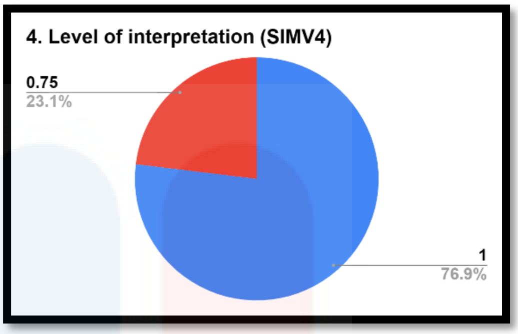
- M-GAM Value


1. Rarity (SIMV1)
0.75
13.0%
0.5
17.4%
1
69.6%

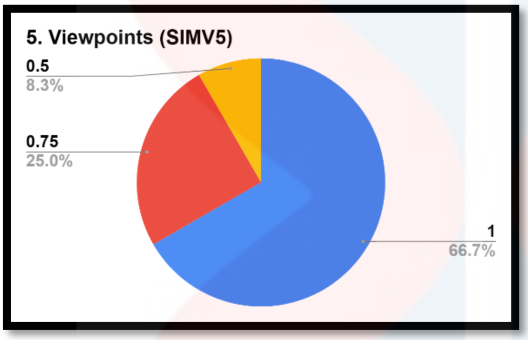

2. Representativeness (SIMV2)
1
100.0%



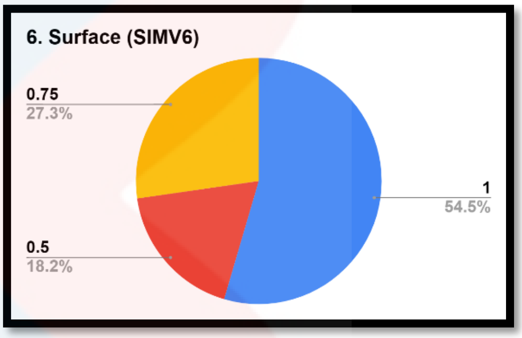
3. Knowledge on geoscientific issues (SIMV3)
0.5
9.5%
0.75
28.6%
0.25
4.8%
1
57.1%



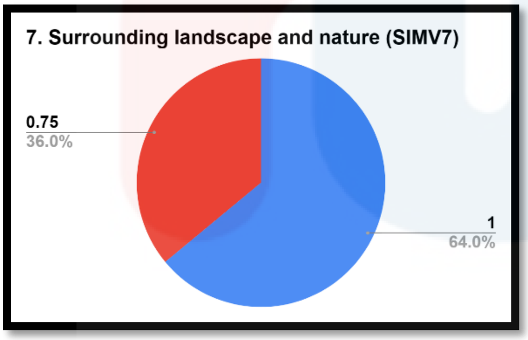
4. Level of interpretation (SIMV4)
0.75
23.1%
1
76.9%



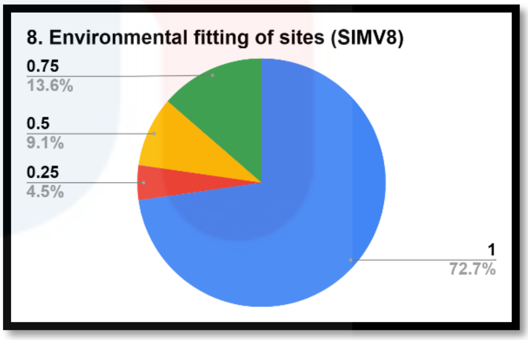
5. Viewpoints (SIMV5)
0.5
8.3%
0.75
25.0%
1
66.7%



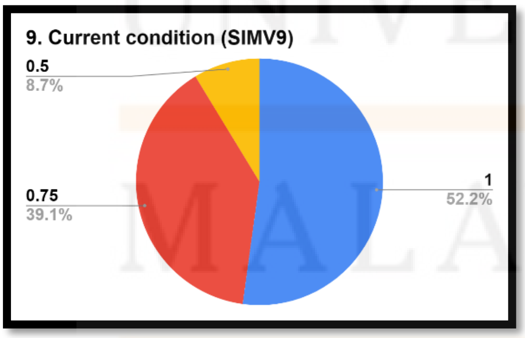
6. Surface (SIMV6)
0.75
27.3%
0.5
18.2%
1
54.5%



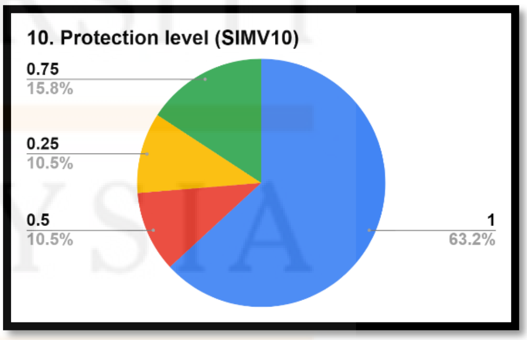
7. Surrounding landscape and nature (SIMV7)
0.75
36.0%
1
64.0%



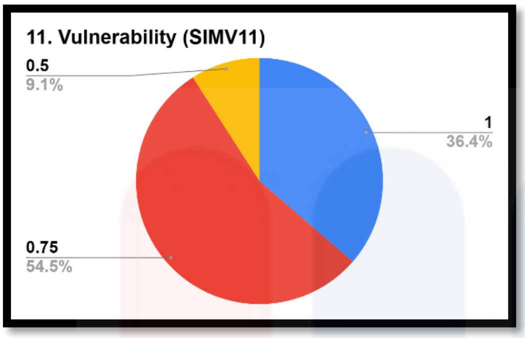
8. Environmental fitting of sites (SIMV8)
0.75
13.6%
0.5
9.1%
0.25
4.5%
1
72.7%

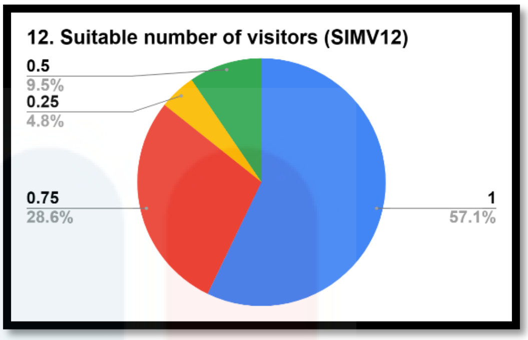


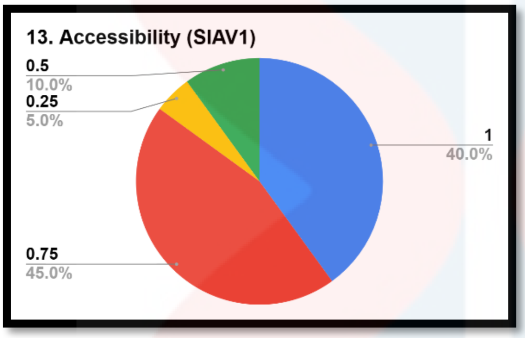
9. Current condition (SIMV9)
0.5
8.7%
0.75
39.1%
1
52.2%

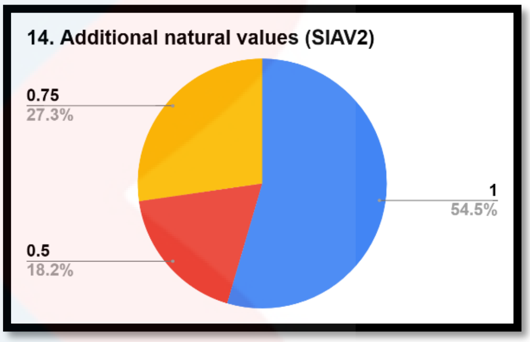


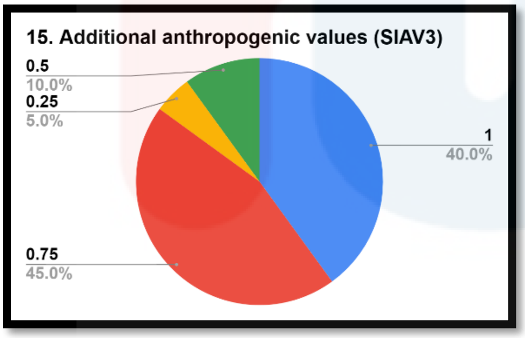
10. Protection level (SIMV10)
0.75
15.8%
0.25
10.5%
0.5
10.5%
1
63.2%

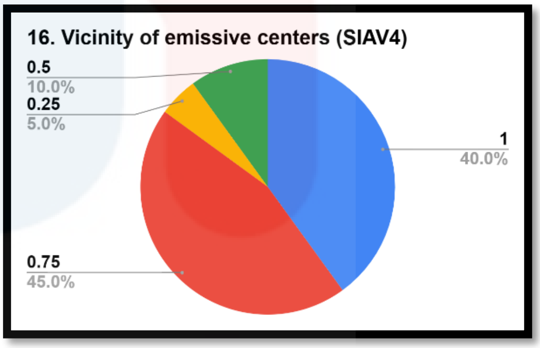

11. Vulnerability (SIMV11)
0.5
9.1%
1
36.4%
0.75
54.5%

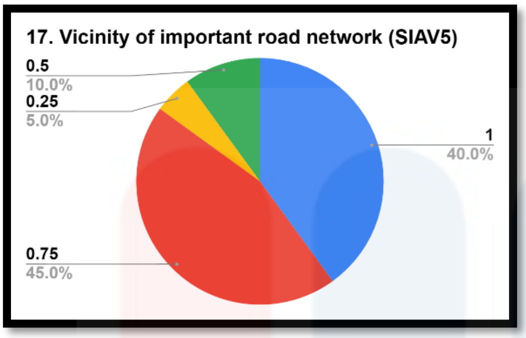

12. Suitable number of visitors (SIMV12)
0.5
9.5%
0.25
4.8%
0.75
28.6%
1
57.1%

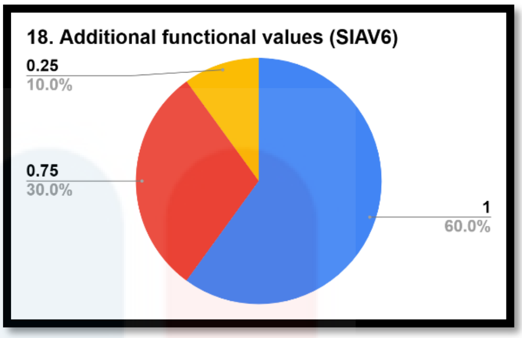

13. Accessibility (SIAV1)
0.5
10.0%
0.25
5.0%
1
40.0%
0.75
45.0%

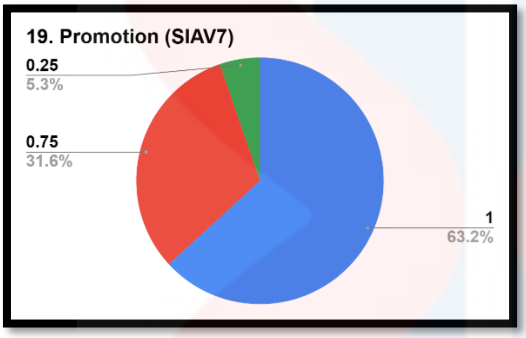

14. Additional natural values (SIAV2)
0.75
27.3%
1
54.5%
0.5
18.2%

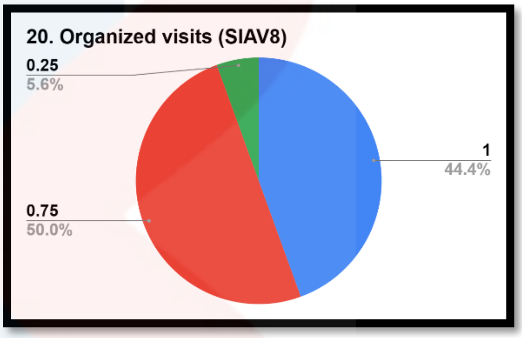

15. Additional anthropogenic values (SIAV3)
0.5
10.0%
0.25
5.0%
1
40.0%
0.75
45.0%

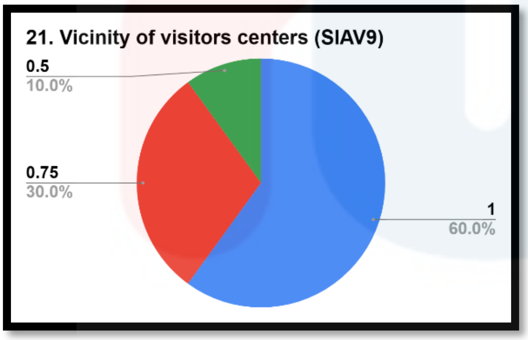

16. Vicinity of emissive centers (SIAV4)
0.5
10.0%
0.25
5.0%
1
40.0%
0.75
45.0%

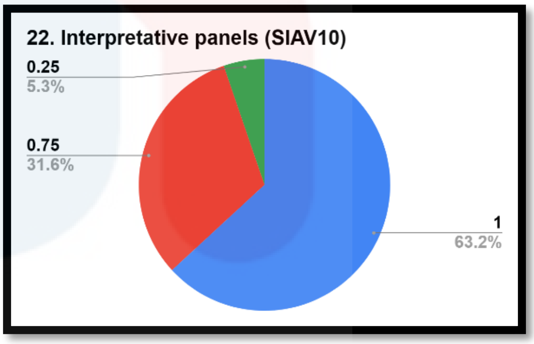

17. Vicinity of important road network (SIAV5)
0.5
10.0%
0.25
5.0%
1
40.0%
0.75
45.0%

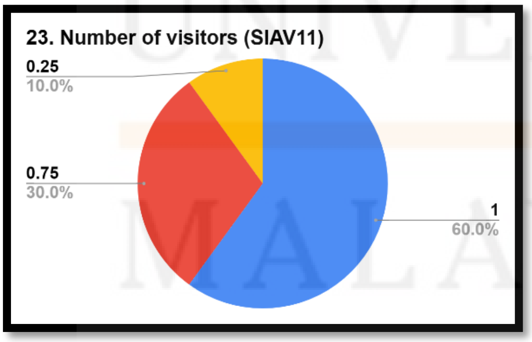

18. Additional functional values (SIAV6)
0.25
10.0%
0.75
30.0%
1
60.0%

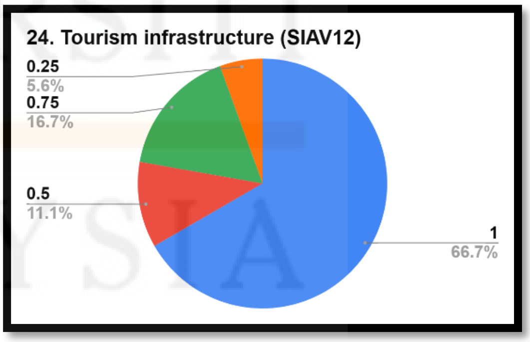

19. Promotion (SIAV7)
0.25
5.3%
0.75
31.6%
1
63.2%

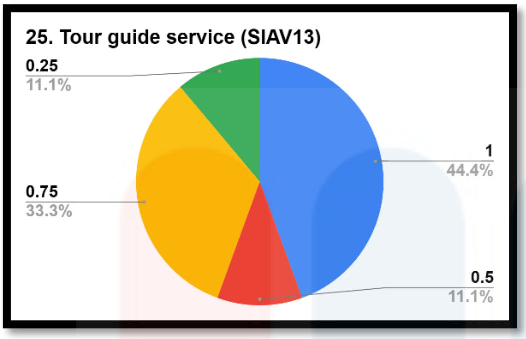

20. Organized visits (SIAV8)
0.25
5.6%
1
44.4%
0.75
50.0%

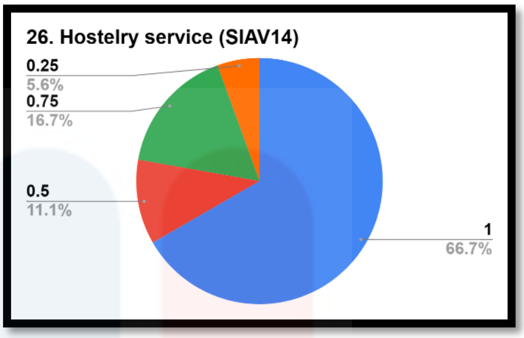

21. Vicinity of visitors centers (SIAV9)
0.5
10.0%
0.75
30.0%
1
60.0%

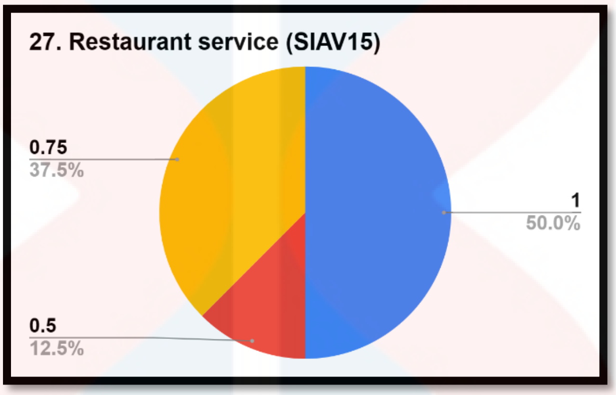

22. Interpretative panels (SIAV10)
0.25
5.3%
0.75
31.6%
1
63.2%


23. Number of visitors (SIAV11)
0.25
10.0%
0.75
30.0%
1
60.0%


24. Tourism infrastructure (SIAV12)
0.25
5.6%
0.75
16.7%
0.5
11.1%
1
66.7%

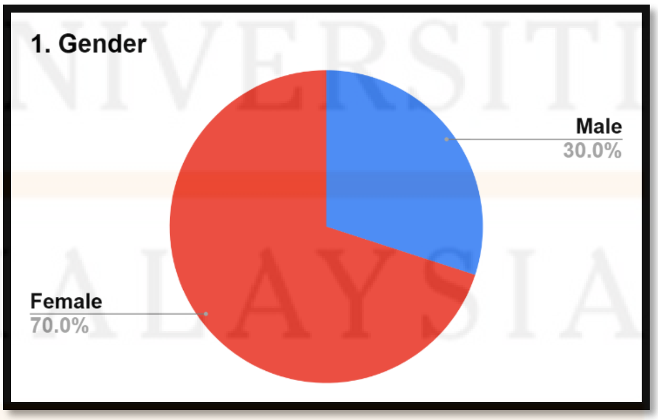


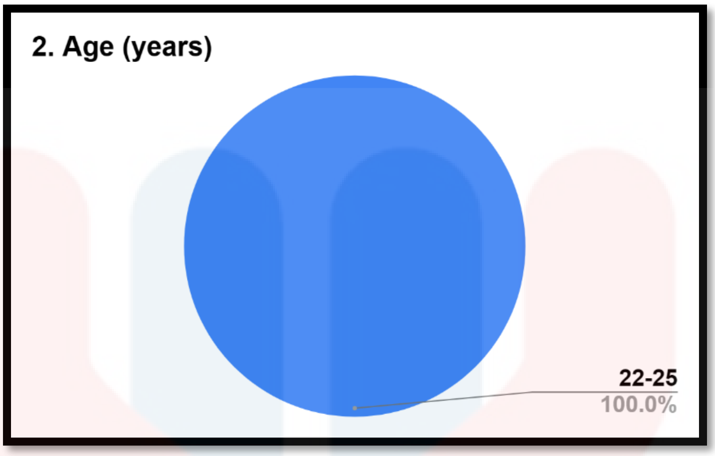


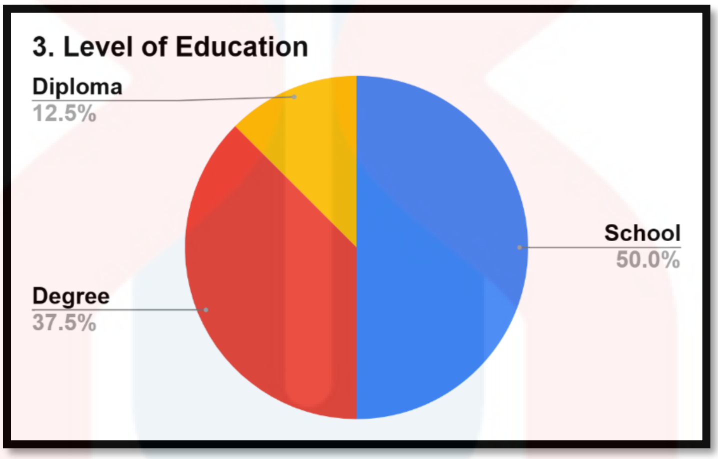


c) Gua Batu Balai

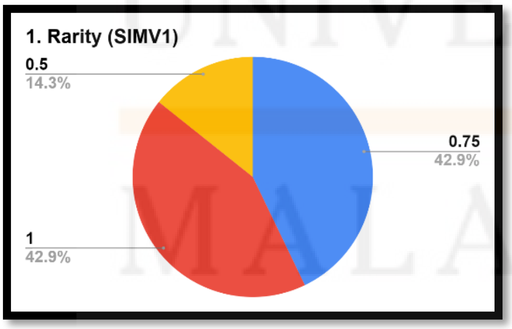
- General

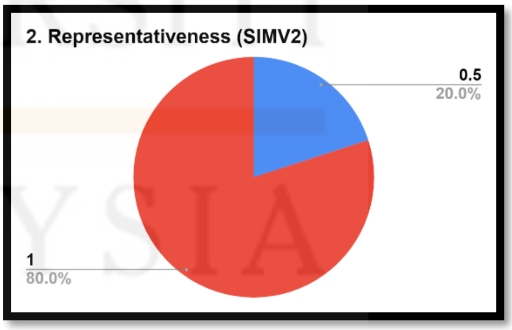


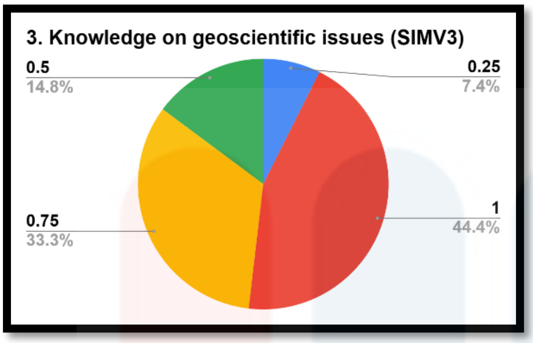

2. Age (years)
22-25
100.0%

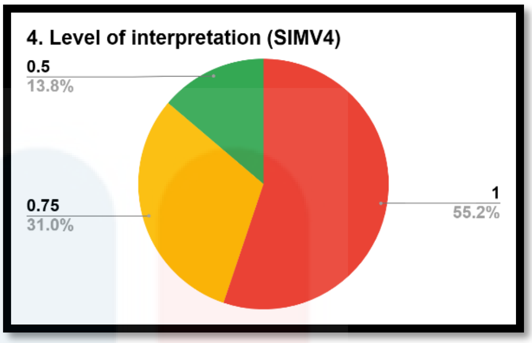

3. Level of Education
Diploma
12.5%
School
50.0%
Degree
37.5%

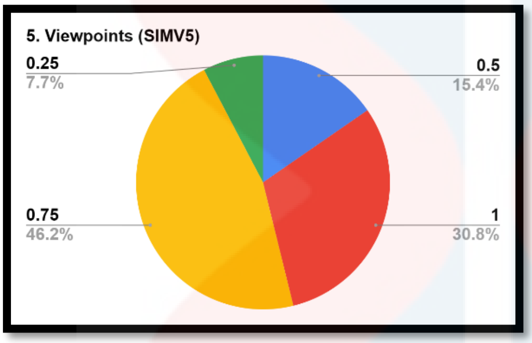
- **M-GAM Value**

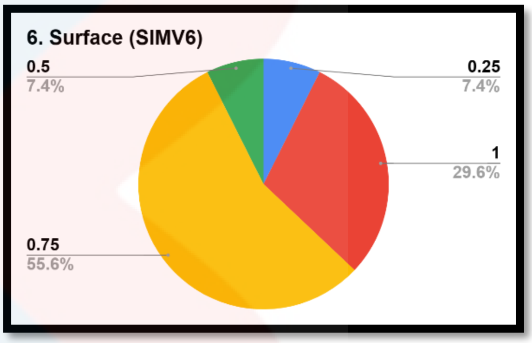

1. Rarity (SIMV1)
0.5
14.3%
0.75
42.9%
1
42.9%

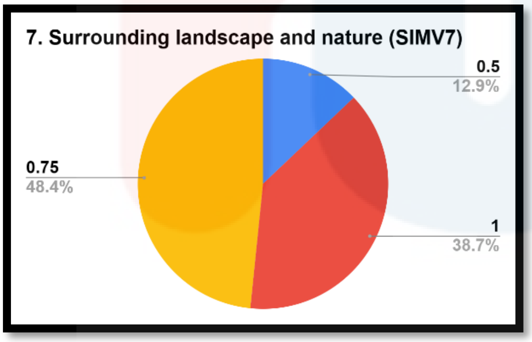

2. Representativeness (SIMV2)
0.5
20.0%
1
80.0%

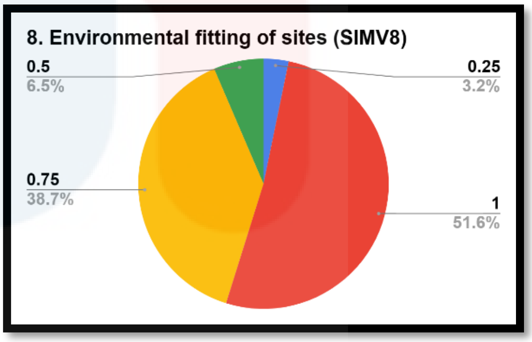

3. Knowledge on geoscientific issues (SIMV3)
0.5
14.8%
0.25
7.4%
0.75
33.3%
1
44.4%

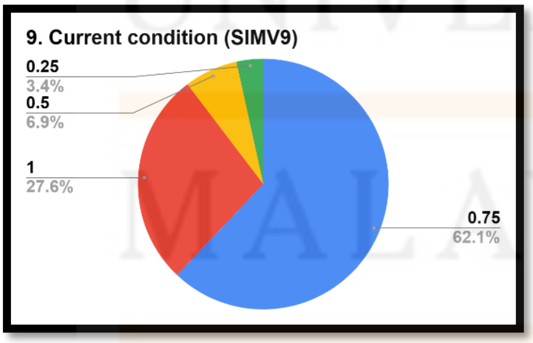

4. Level of interpretation (SIMV4)
0.5
13.8%
0.75
31.0%
1
55.2%

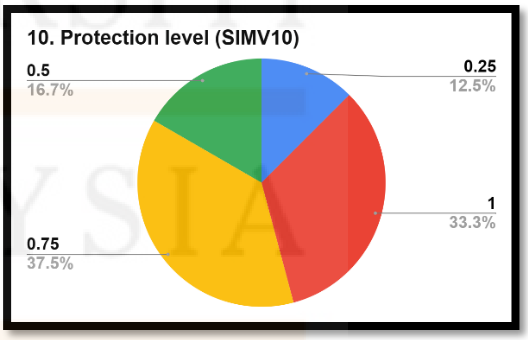

5. Viewpoints (SIMV5)
0.25
7.7%
0.5
15.4%
0.75
46.2%
1
30.8%

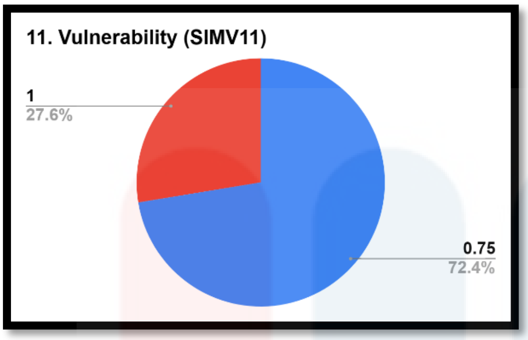

6. Surface (SIMV6)
0.5
7.4%
0.25
7.4%
1
29.6%
0.75
55.6%

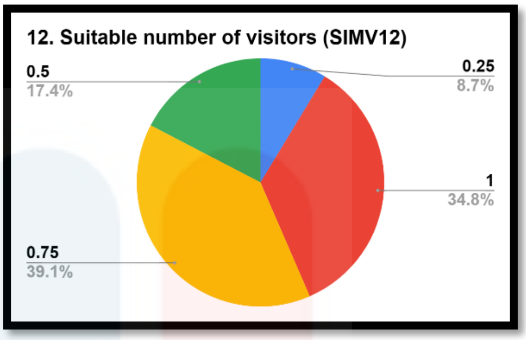

7. Surrounding landscape and nature (SIMV7)
0.5
12.9%
0.75
48.4%
1
38.7%

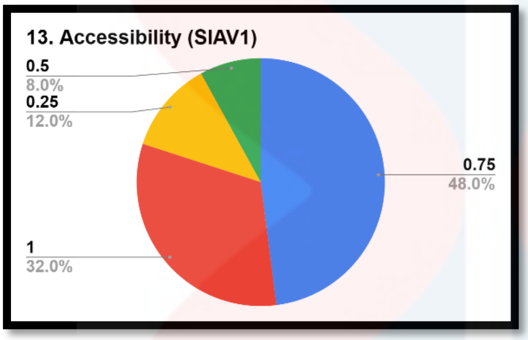

8. Environmental fitting of sites (SIMV8)
0.5
6.5%
0.25
3.2%
0.75
38.7%
1
51.6%

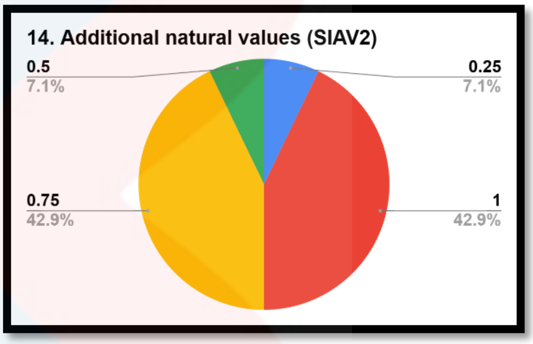

9. Current condition (SIMV9)
0.25
3.4%
0.5
6.9%
1
27.6%
0.75
62.1%

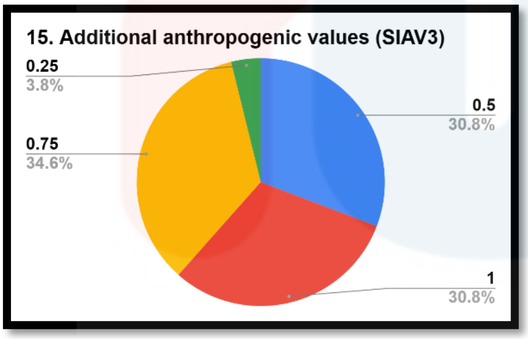

10. Protection level (SIMV10)
0.5
16.7%
0.25
12.5%
1
33.3%
0.75
37.5%

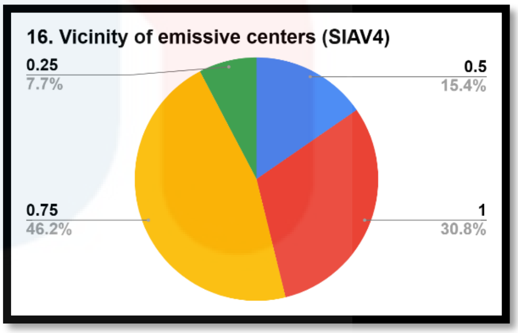

11. Vulnerability (SIMV11)
1
27.6%
0.75
72.4%

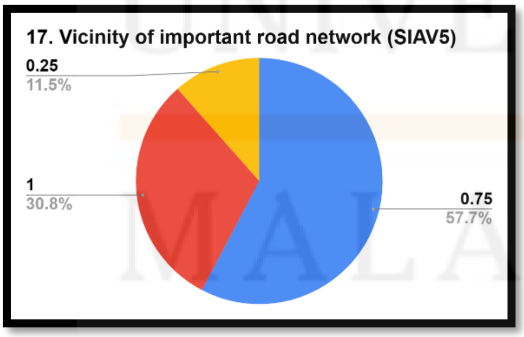

12. Suitable number of visitors (SIMV12)
0.5
17.4%
0.25
8.7%
1
34.8%
0.75
39.1%

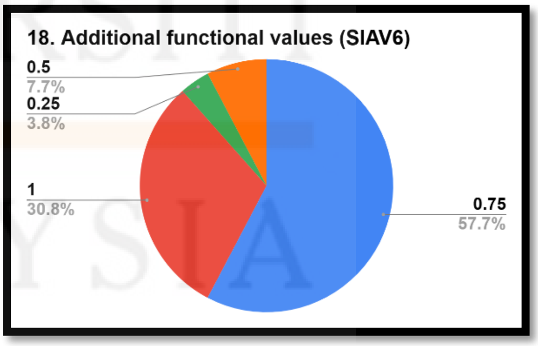

13. Accessibility (SIAV1)
0.5
8.0%
0.25
12.0%
0.75
48.0%
1
32.0%

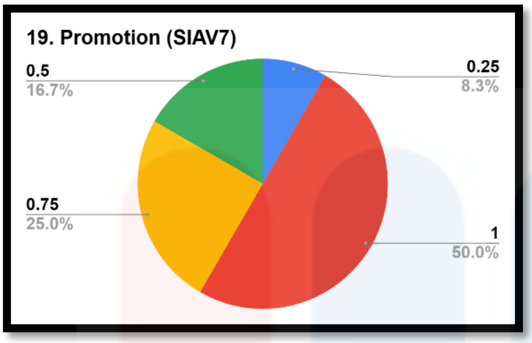

14. Additional natural values (SIAV2)
0.5
7.1%
0.25
7.1%
0.75
42.9%
1
42.9%

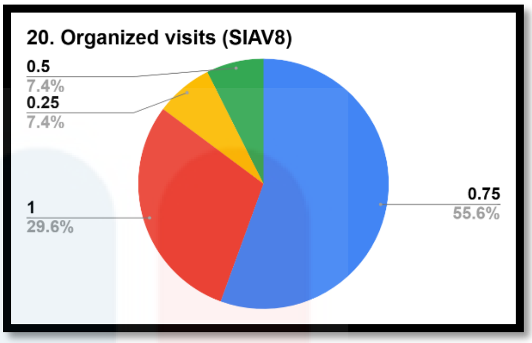

15. Additional anthropogenic values (SIAV3)
0.25
3.8%
0.5
30.8%
0.75
34.6%
1
30.8%

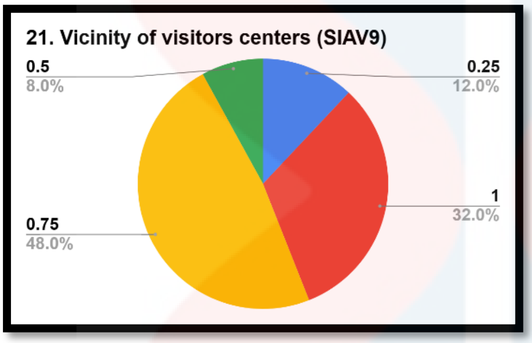

16. Vicinity of emissive centers (SIAV4)
0.25
7.7%
0.5
15.4%
0.75
46.2%
1
30.8%

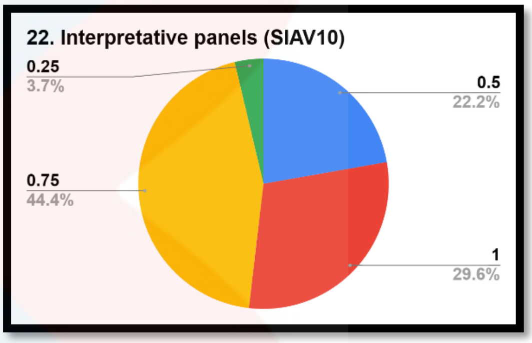

17. Vicinity of important road network (SIAV5)
0.25
11.5%
1
30.8%
0.75
57.7%

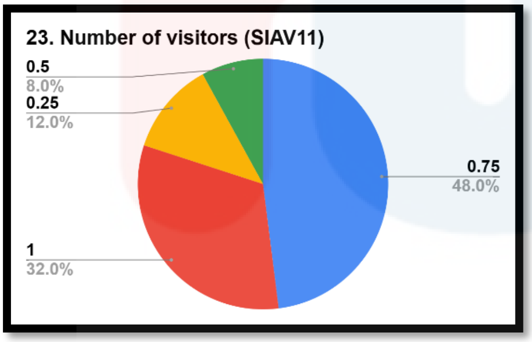

18. Additional functional values (SIAV6)
0.5
7.7%
0.25
3.8%
1
30.8%
0.75
57.7%

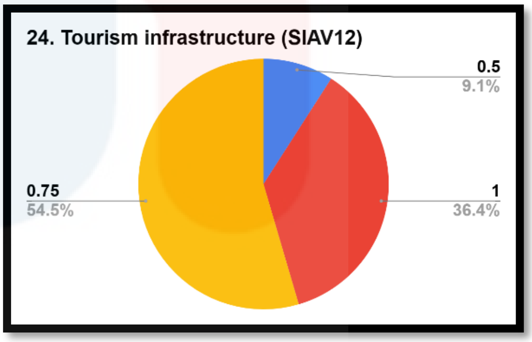

19. Promotion (SIAV7)
0.5
16.7%
0.25
8.3%
0.75
25.0%
1
50.0%

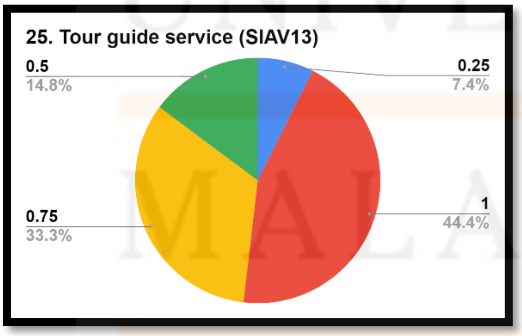

20. Organized visits (SIAV8)
0.5
7.4%
0.25
7.4%
0.75
55.6%
1
29.6%

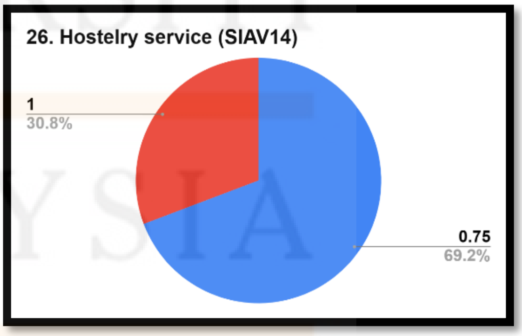

21. Vicinity of visitors centers (SIAV9)
0.5
8.0%
0.25
12.0%
1
32.0%
0.75
48.0%

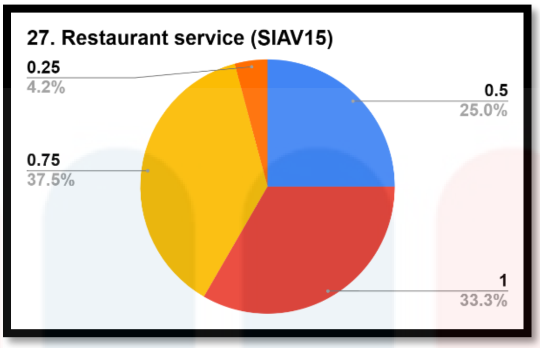

22. Interpretative panels (SIAV10)
0.25
3.7%
0.5
22.2%
0.75
44.4%
1
29.6%


23. Number of visitors (SIAV11)
0.5
8.0%
0.25
12.0%
0.75
48.0%
1
32.0%


24. Tourism infrastructure (SIAV12)
0.5
9.1%
0.75
54.5%
1
36.4%

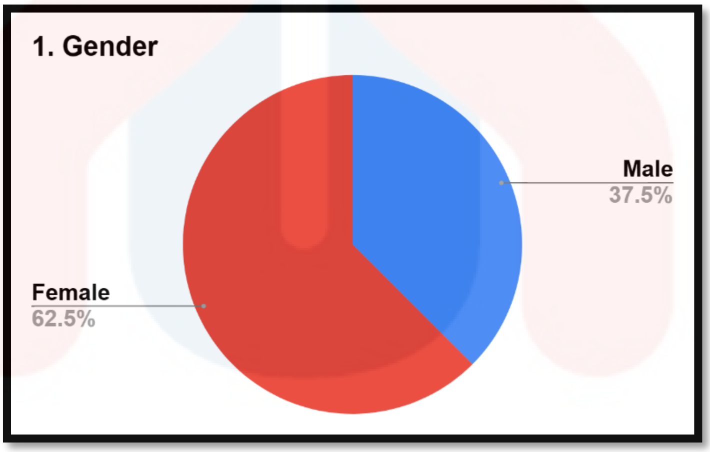

25. Tour guide service (SIAV13)
0.5
14.8%
0.25
7.4%
0.75
33.3%
1
44.4%

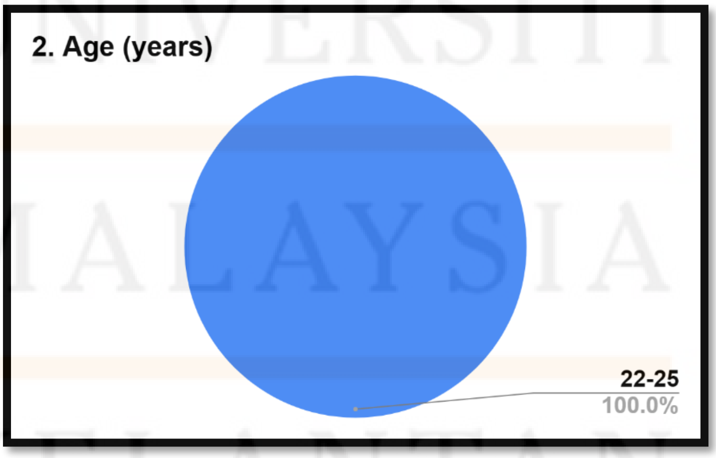

26. Hostelry service (SIAV14)
1
30.8%
0.75
69.2%

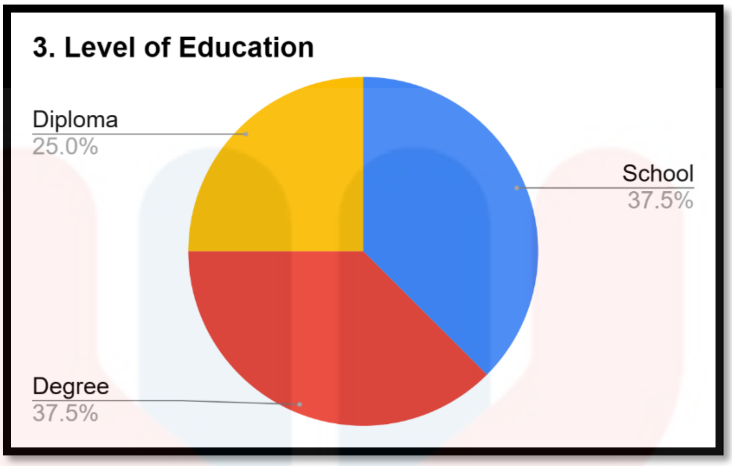


d) Gua Kawah

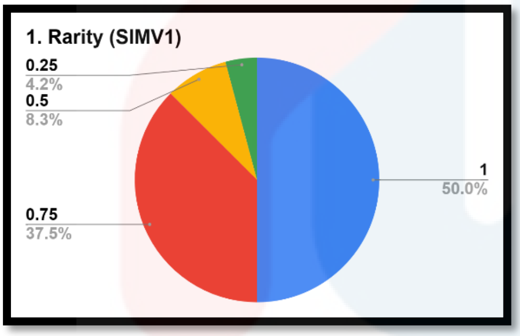
- General

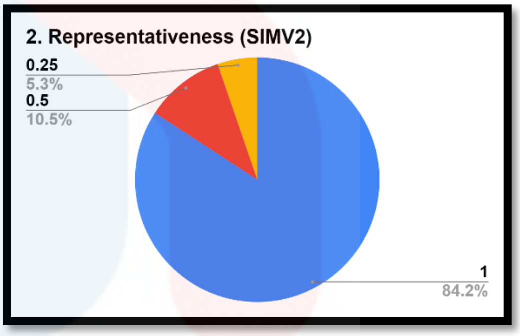


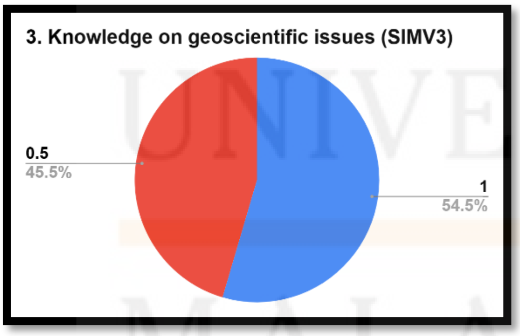


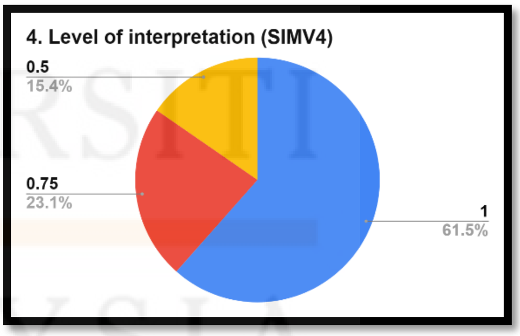

3. Level of Education
Diploma
25.0%
School
37.5%
Degree
37.5%

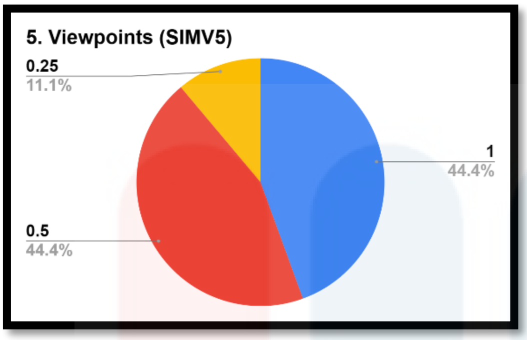
- M-GAM Value

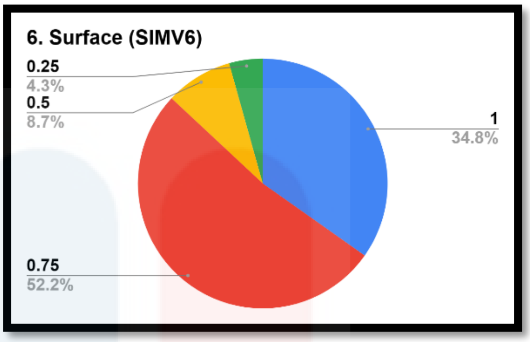

1. Rarity (SIMV1)
0.25
4.2%
0.5
8.3%
0.75
37.5%
1
50.0%

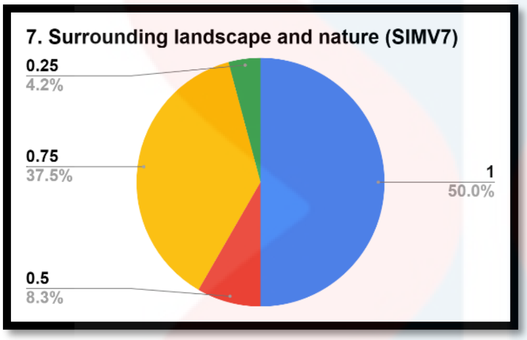

2. Representativeness (SIMV2)
0.25
5.3%
0.5
10.5%
1
84.2%

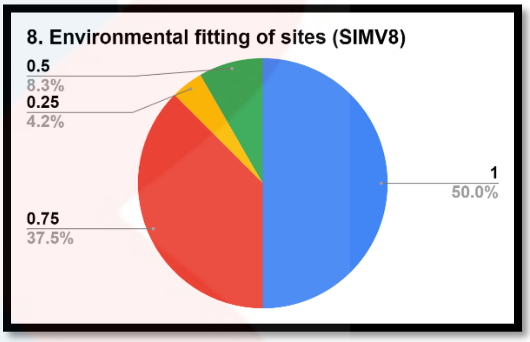

3. Knowledge on geoscientific issues (SIMV3)
0.5
45.5%
1
54.5%

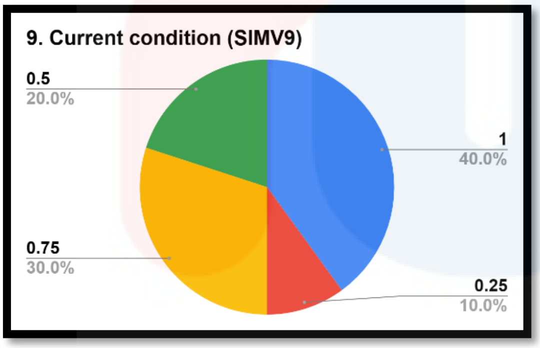

4. Level of interpretation (SIMV4)
0.5
15.4%
0.75
23.1%
1
61.5%

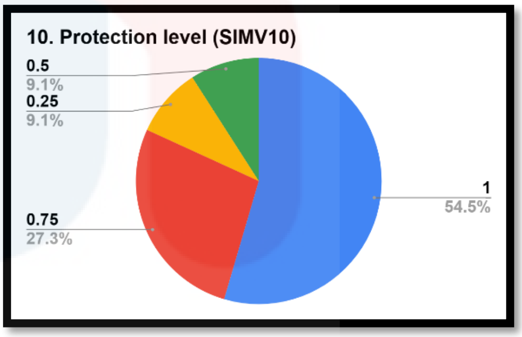

5. Viewpoints (SIMV5)
0.25
11.1%
1
44.4%
0.5
44.4%

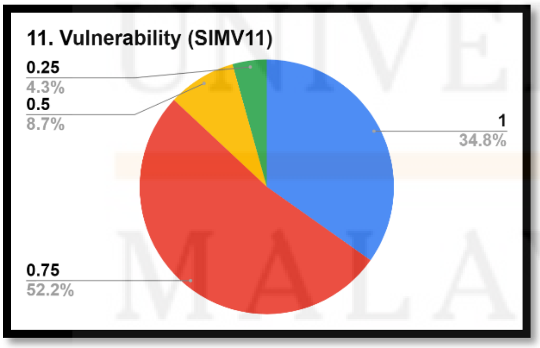

6. Surface (SIMV6)
0.25
4.3%
0.5
8.7%
1
34.8%
0.75
52.2%

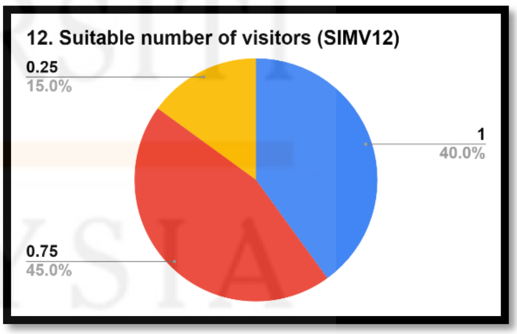

7. Surrounding landscape and nature (SIMV7)
0.25
4.2%
0.75
37.5%
1
50.0%
0.5
8.3%

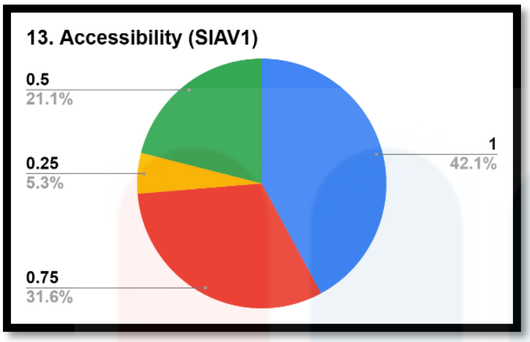

8. Environmental fitting of sites (SIMV8)
0.5
8.3%
0.25
4.2%
1
50.0%
0.75
37.5%


9. Current condition (SIMV9)
0.5
20.0%
1
40.0%
0.75
30.0%
0.25
10.0%

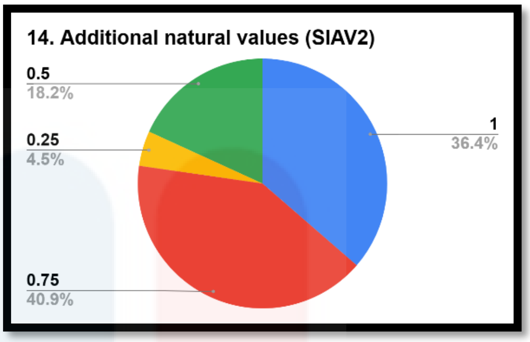

10. Protection level (SIMV10)
0.5
9.1%
0.25
9.1%
1
54.5%
0.75
27.3%


11. Vulnerability (SIMV11)
0.25
4.3%
0.5
8.7%
1
34.8%
0.75
52.2%

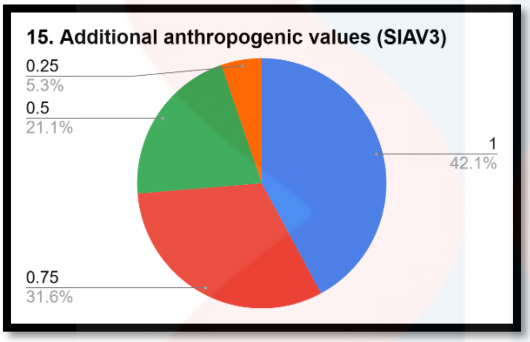

12. Suitable number of visitors (SIMV12)
0.25
15.0%
1
40.0%
0.75
45.0%



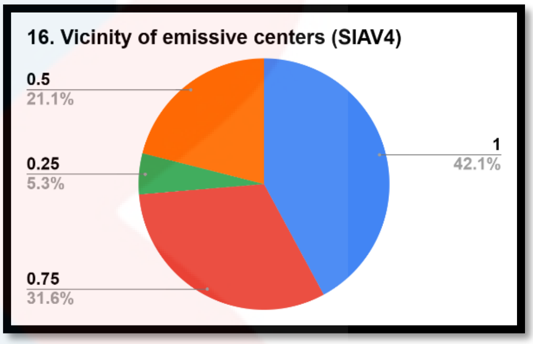
13. Accessibility (SIAV1)



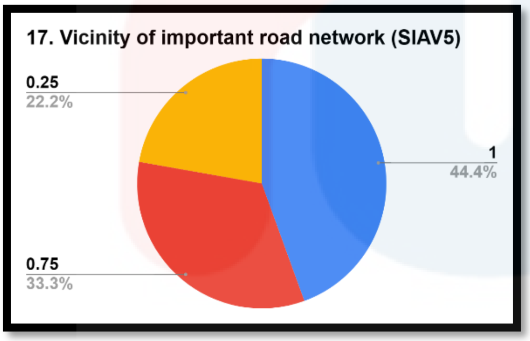
14. Additional natural values (SIAV2)



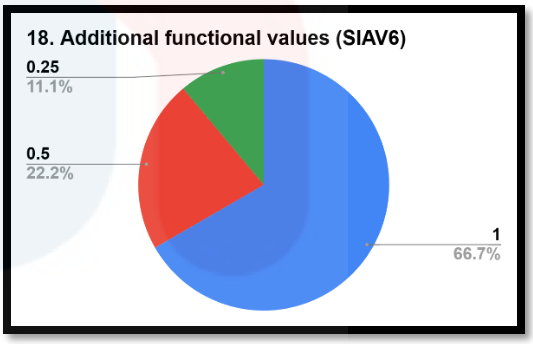
15. Additional anthropogenic values (SIAV3)



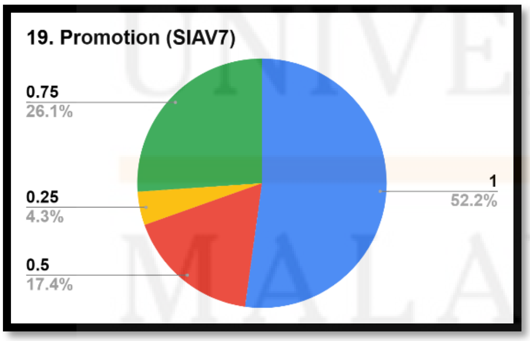
16. Vicinity of emissive centers (SIAV4)



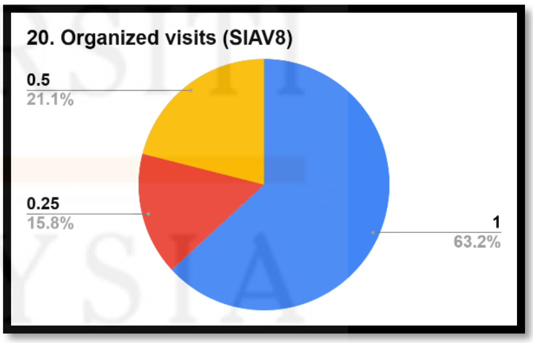
17. Vicinity of important road network (SIAV5)



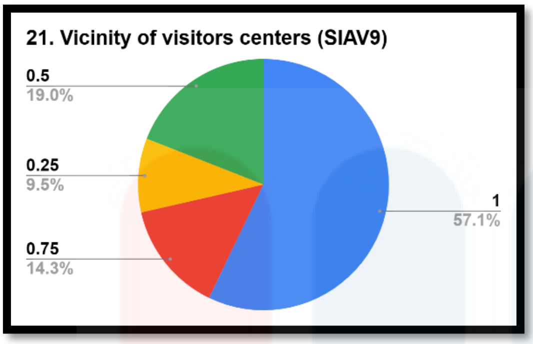
18. Additional functional values (SIAV6)

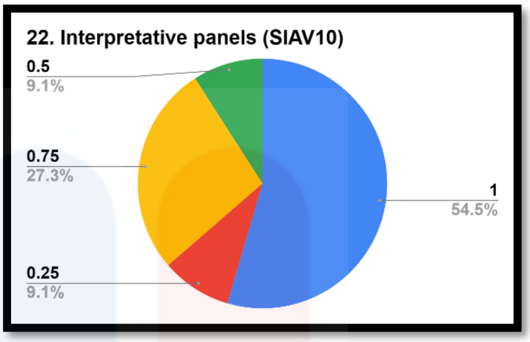


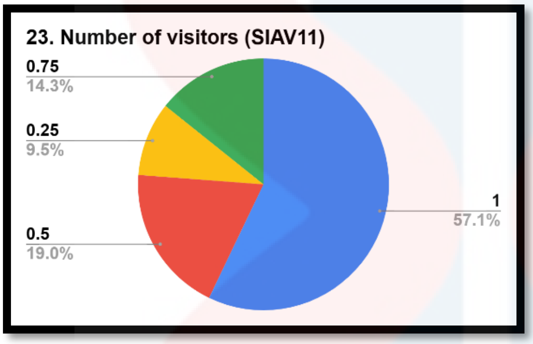
19. Promotion (SIAV7)

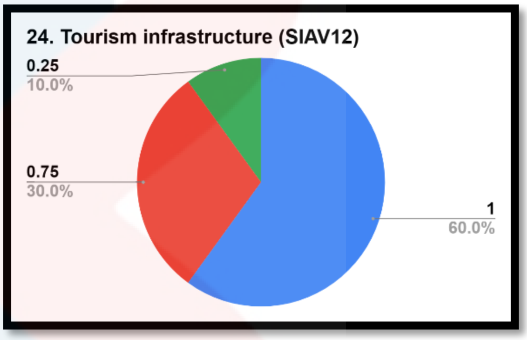


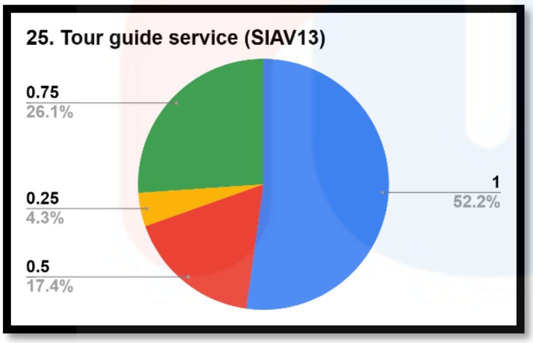
20. Organized visits (SIAV8)

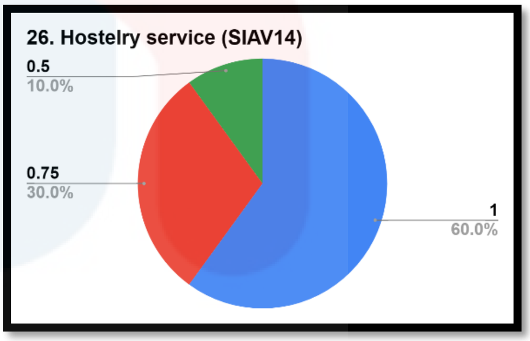


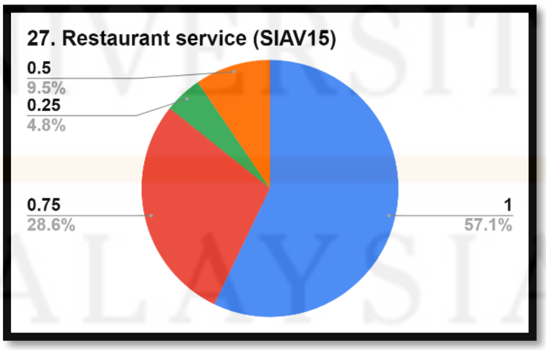






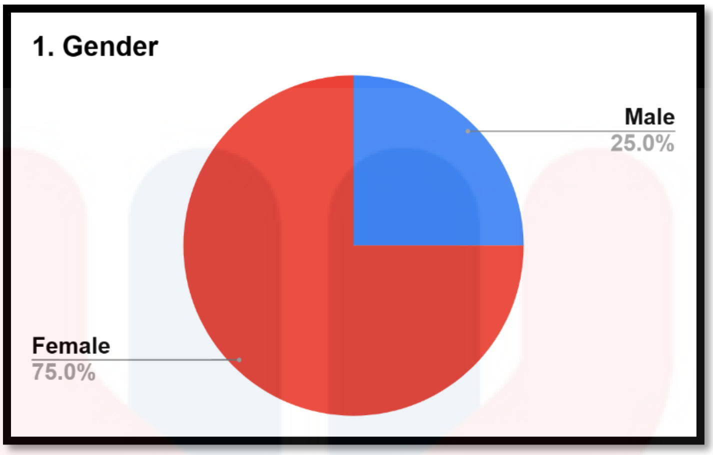


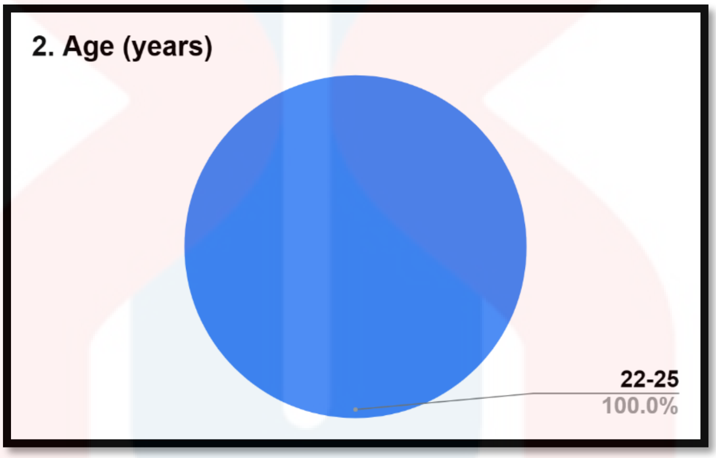


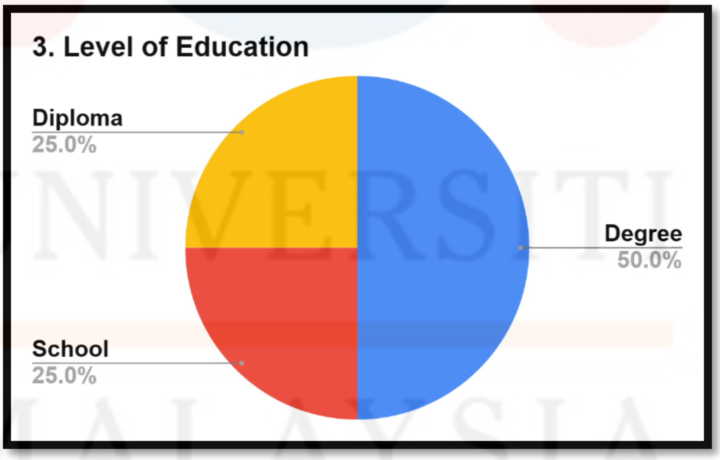


e) Gua Paha Kerbau

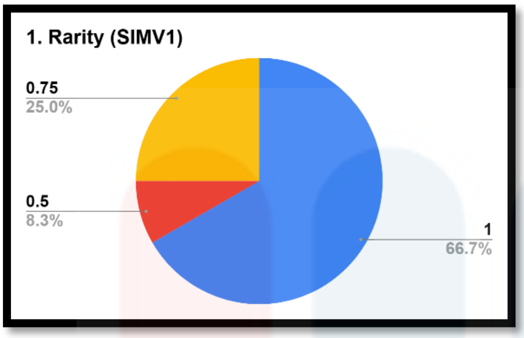
- General

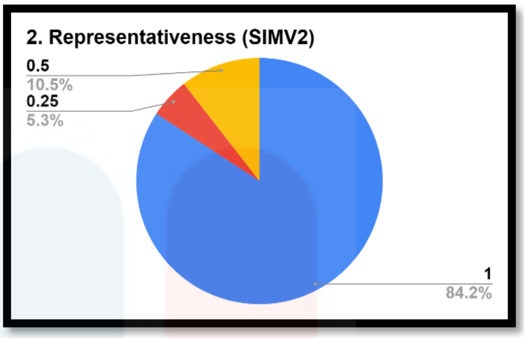

1. Gender
Male
25.0%
Female
75.0%

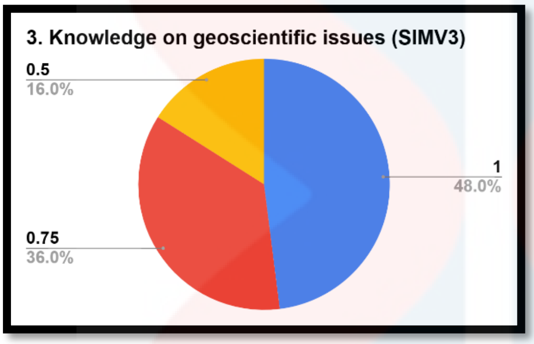

2. Age (years)
22-25
100.0%

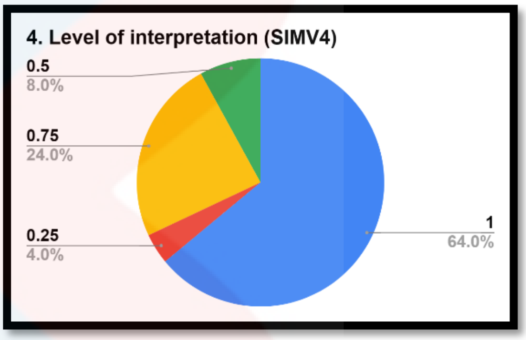

3. Level of Education
Diploma
25.0%
Degree
50.0%
School
25.0%

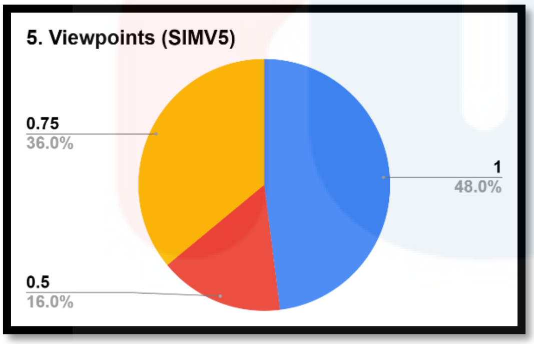
- M-GAM Value

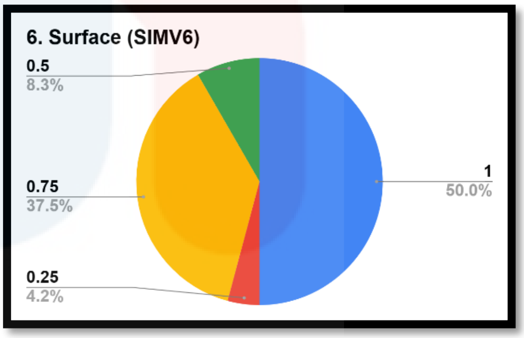

1. Rarity (SIMV1)
0.75
25.0%
0.5
8.3%
1
66.7%

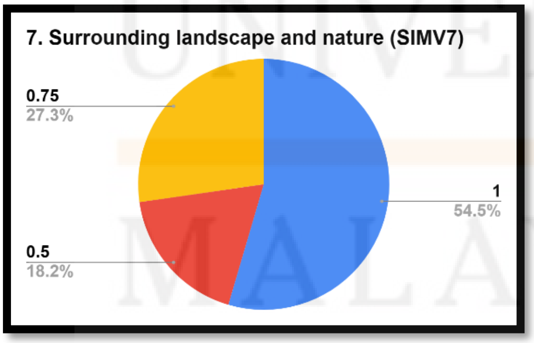

2. Representativeness (SIMV2)
0.5
10.5%
0.25
5.3%
1
84.2%

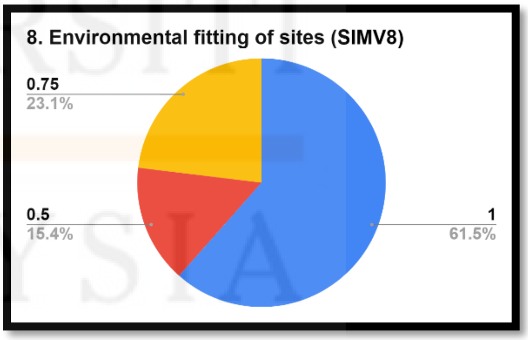

3. Knowledge on geoscientific issues (SIMV3)
0.5
16.0%
1
48.0%
0.75
36.0%

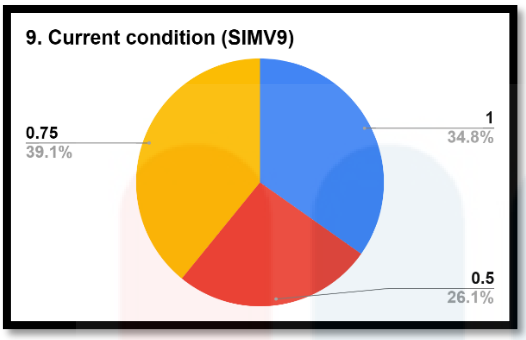

4. Level of interpretation (SIMV4)
0.5
8.0%
0.75
24.0%
1
64.0%
0.25
4.0%

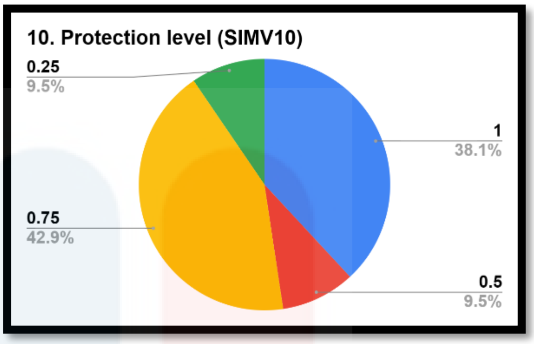

5. Viewpoints (SIMV5)
0.75
36.0%
1
48.0%
0.5
16.0%

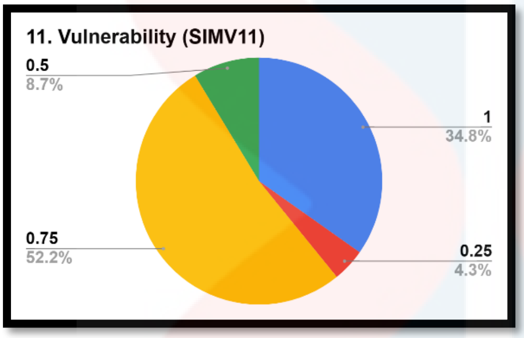

6. Surface (SIMV6)
0.5
8.3%
0.75
37.5%
1
50.0%
0.25
4.2%

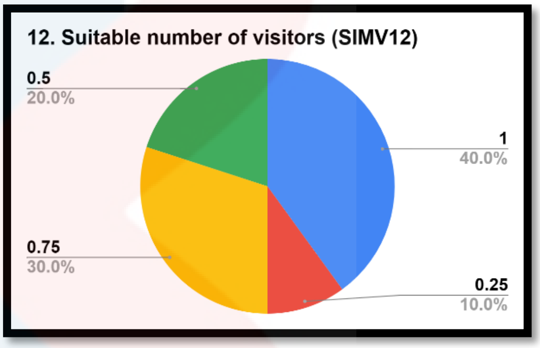

7. Surrounding landscape and nature (SIMV7)
0.75
27.3%
1
54.5%
0.5
18.2%

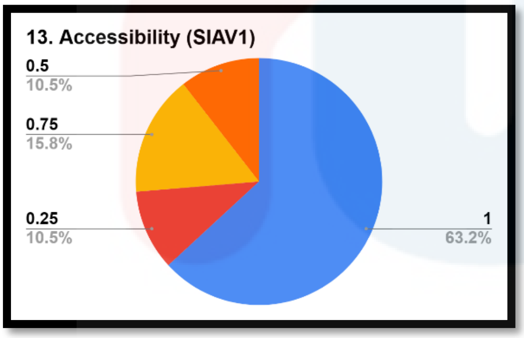

8. Environmental fitting of sites (SIMV8)
0.75
23.1%
0.5
15.4%
1
61.5%

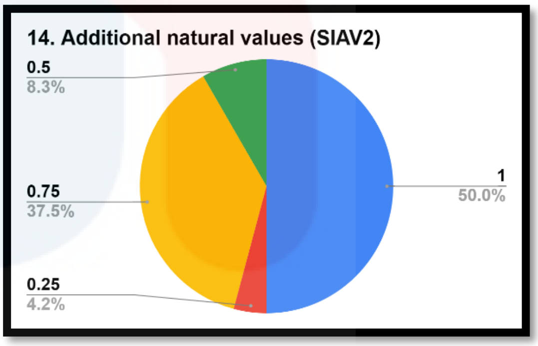

9. Current condition (SIMV9)
0.75
39.1%
1
34.8%
0.5
26.1%

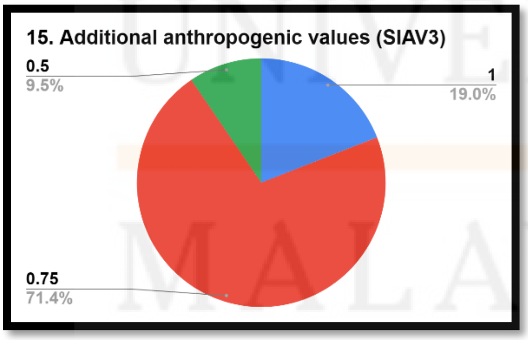

10. Protection level (SIMV10)
0.25
9.5%
1
38.1%
0.75
42.9%
0.5
9.5%

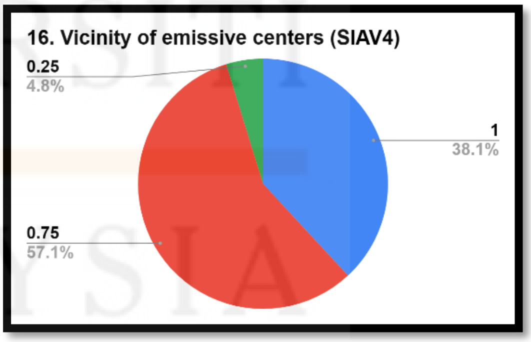

11. Vulnerability (SIMV11)
0.5
8.7%
1
34.8%
0.75
52.2%
0.25
4.3%

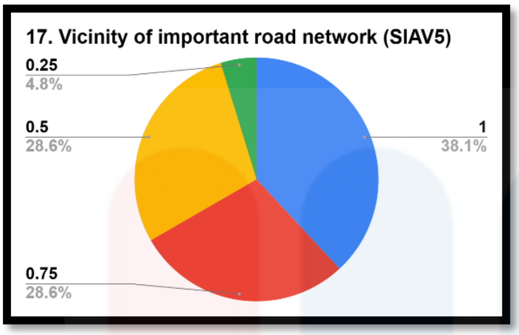

12. Suitable number of visitors (SIMV12)
0.5
20.0%
1
40.0%
0.75
30.0%
0.25
10.0%

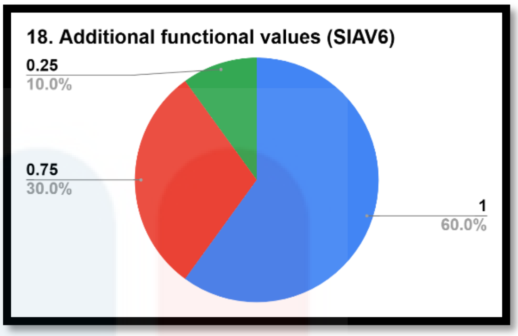

13. Accessibility (SIAV1)
0.5
10.5%
0.75
15.8%
0.25
10.5%
1
63.2%

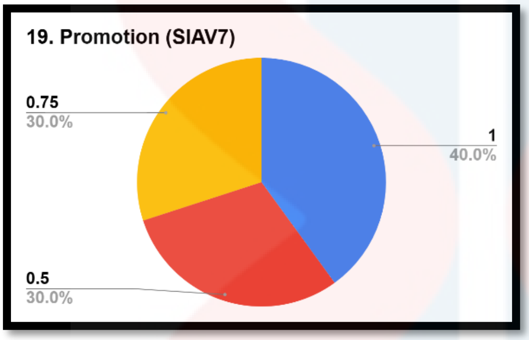

14. Additional natural values (SIAV2)
0.5
8.3%
1
50.0%
0.75
37.5%
0.25
4.2%

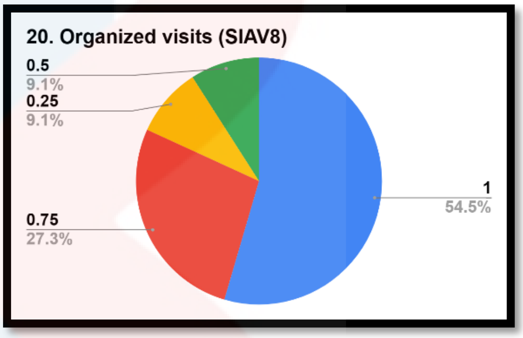

15. Additional anthropogenic values (SIAV3)
0.5
9.5%
1
19.0%
0.75
71.4%

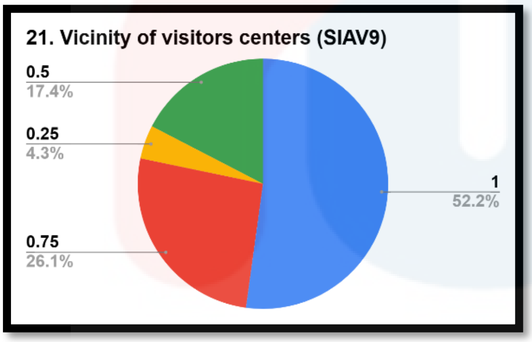

16. Vicinity of emissive centers (SIAV4)
0.25
4.8%
1
38.1%
0.75
57.1%

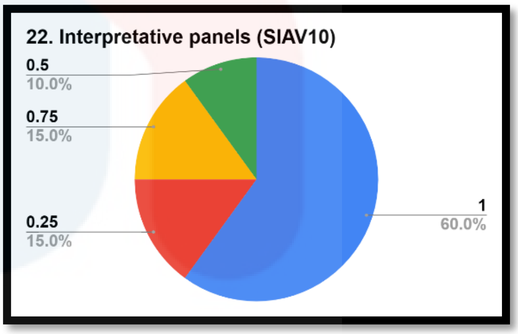

17. Vicinity of important road network (SIAV5)
0.25
4.8%
0.5
28.6%
0.75
28.6%
1
38.1%

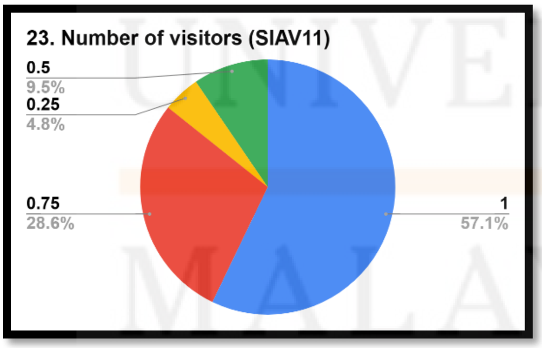

18. Additional functional values (SIAV6)
0.25
10.0%
0.75
30.0%
1
60.0%

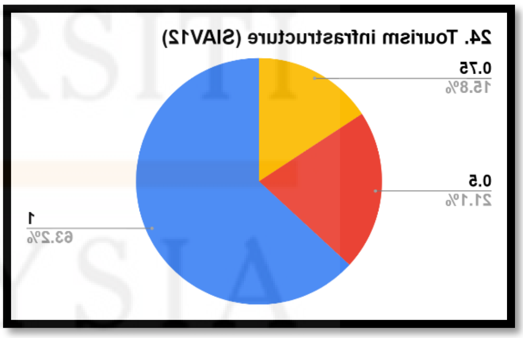

19. Promotion (SIAV7)
0.75
30.0%
0.5
30.0%
1
40.0%

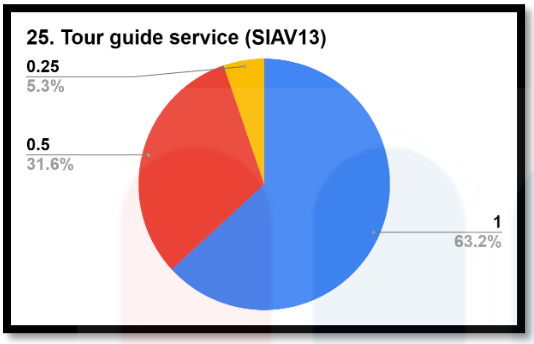

20. Organized visits (SIAV8)
0.5
9.1%
0.25
9.1%
0.75
27.3%
1
54.5%

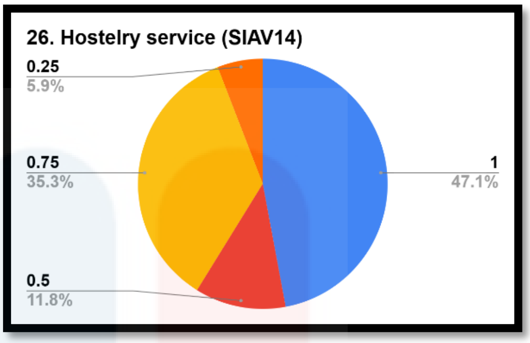

21. Vicinity of visitors centers (SIAV9)
0.5
17.4%
0.25
4.3%
0.75
26.1%
1
52.2%

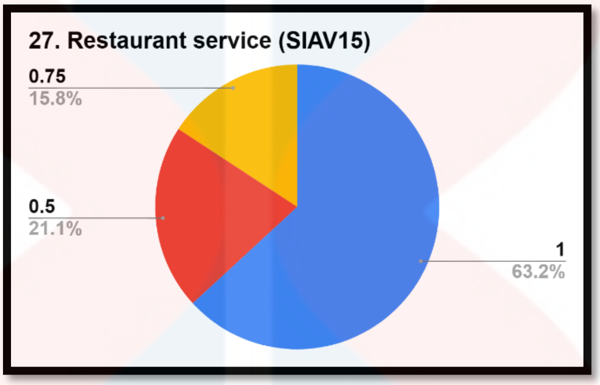

22. Interpretative panels (SIAV10)
0.5
10.0%
0.75
15.0%
0.25
15.0%
1
60.0%


23. Number of visitors (SIAV11)
0.5
9.5%
0.25
4.8%
0.75
28.6%
1
57.1%


24. Tourism infrastructure (SIAV12)
0.75
15.8%
0.5
21.1%
1
63.2%

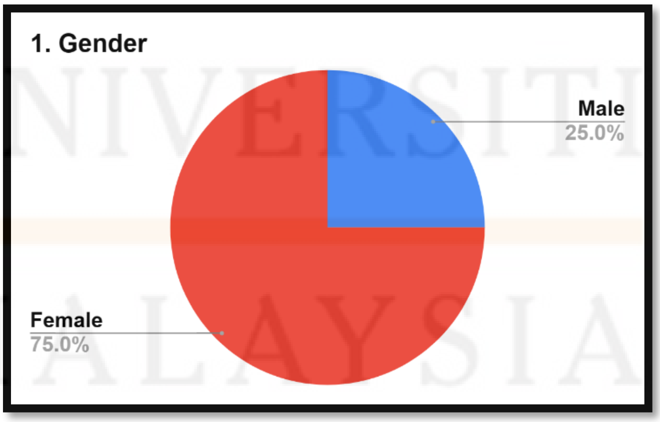


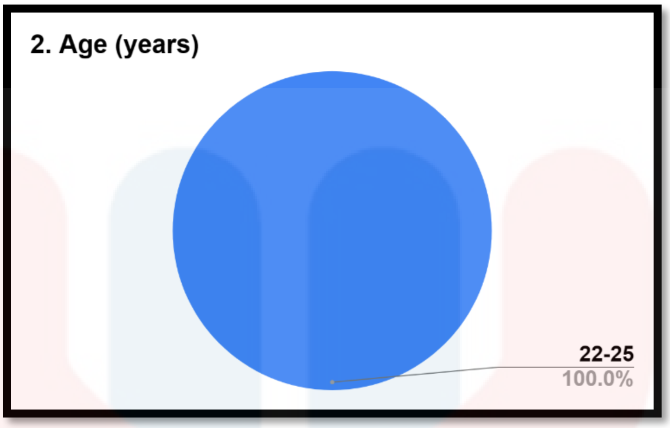


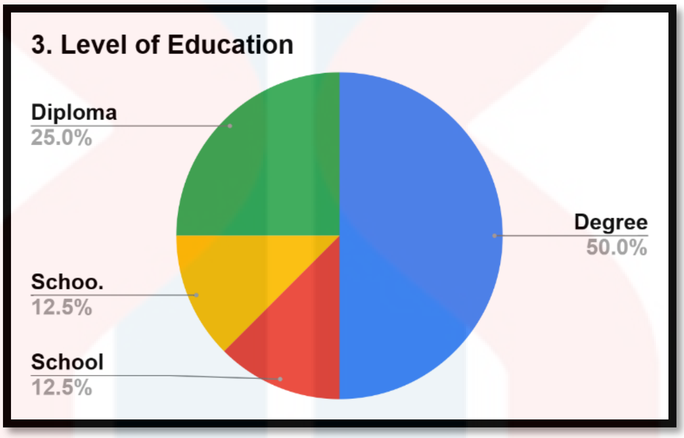


f) Gua Kurap

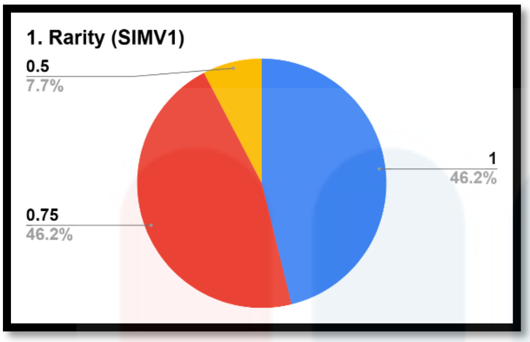
- General

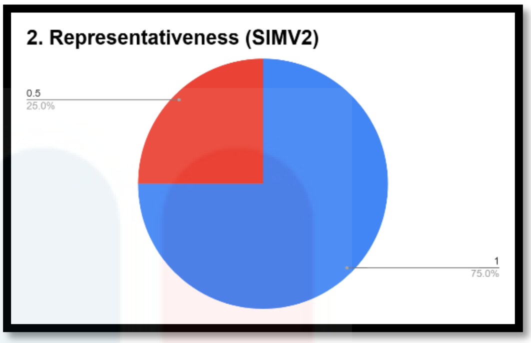


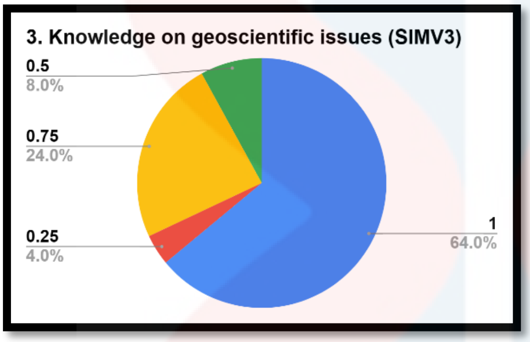

2. Age (years)
22-25
100.0%

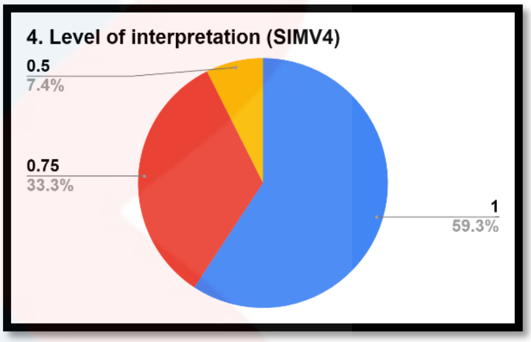

3. Level of Education
Diploma
25.0%
Degree
50.0%
Schoo.
12.5%
School
12.5%

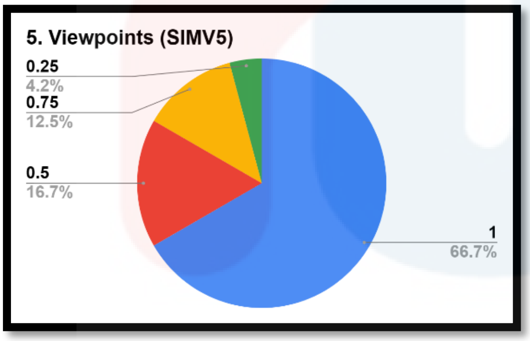
- M-GAM Value

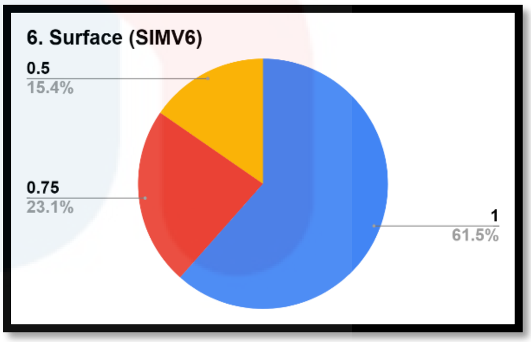

1. Rarity (SIMV1)
0.5
7.7%
1
46.2%
0.75
46.2%

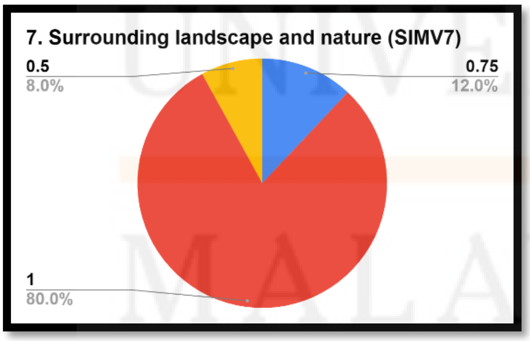

2. Representativeness (SIMV2)
0.5
25.0%
1
75.0%

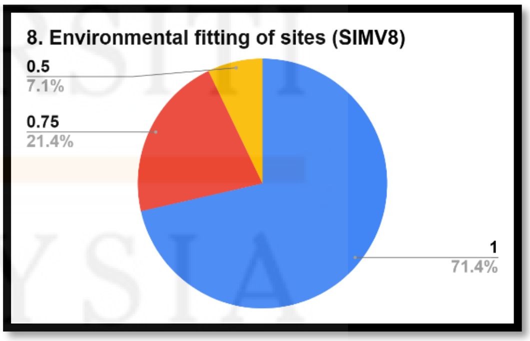

3. Knowledge on geoscientific issues (SIMV3)
0.5
8.0%
0.75
24.0%
1
64.0%
0.25
4.0%

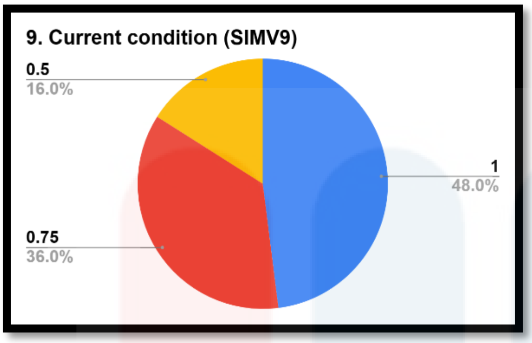

4. Level of interpretation (SIMV4)
0.5
7.4%
0.75
33.3%
1
59.3%

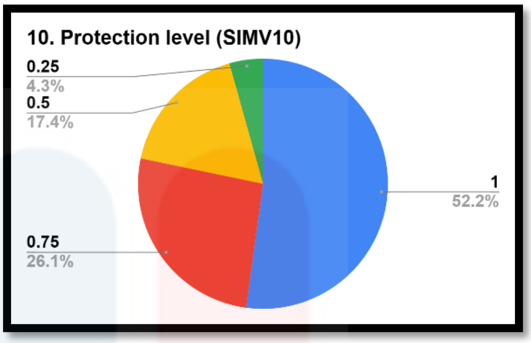

5. Viewpoints (SIMV5)
0.25
4.2%
0.75
12.5%
0.5
16.7%
1
66.7%

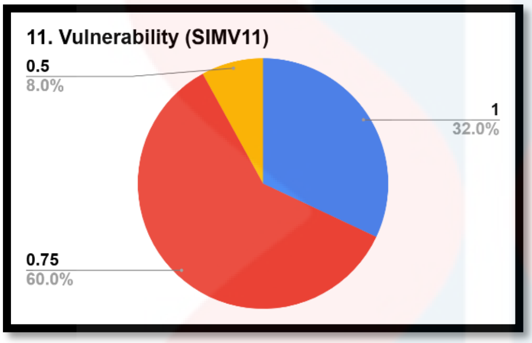

6. Surface (SIMV6)
0.5
15.4%
0.75
23.1%
1
61.5%

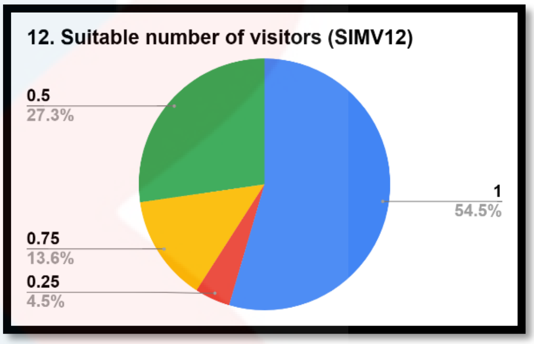

7. Surrounding landscape and nature (SIMV7)
0.5
8.0%
0.75
12.0%
1
80.0%

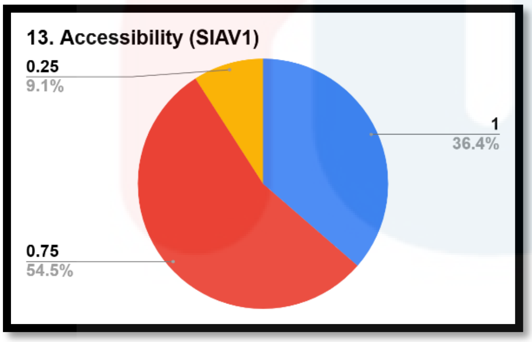

8. Environmental fitting of sites (SIMV8)
0.5
7.1%
0.75
21.4%
1
71.4%

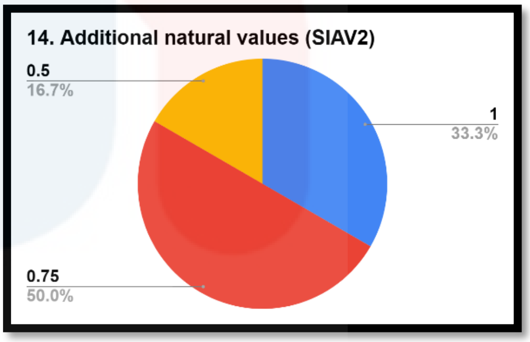

9. Current condition (SIMV9)
0.5
16.0%
1
48.0%
0.75
36.0%

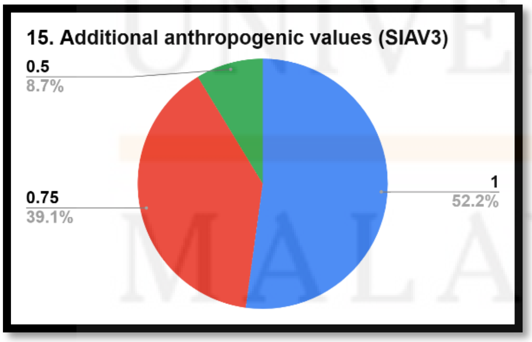

10. Protection level (SIMV10)
0.25
4.3%
0.5
17.4%
1
52.2%
0.75
26.1%

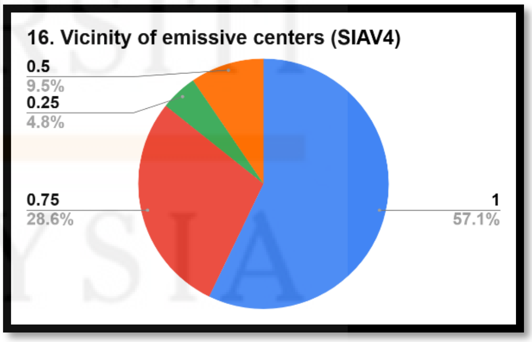

11. Vulnerability (SIMV11)
0.5
8.0%
1
32.0%
0.75
60.0%

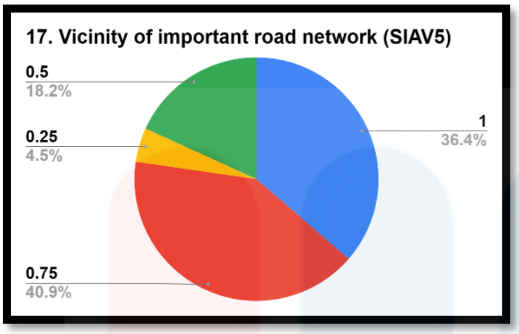

12. Suitable number of visitors (SIMV12)
0.5
27.3%
1
54.5%
0.75
13.6%
0.25
4.5%

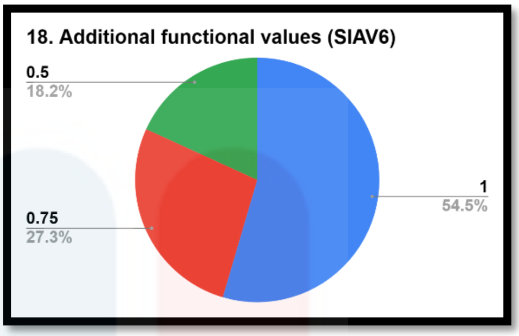

13. Accessibility (SIAV1)
0.25
9.1%
1
36.4%
0.75
54.5%

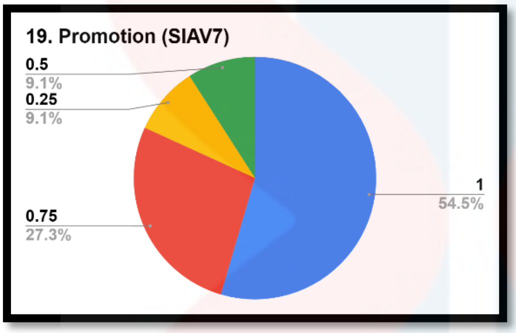

14. Additional natural values (SIAV2)
0.5
16.7%
1
33.3%
0.75
50.0%

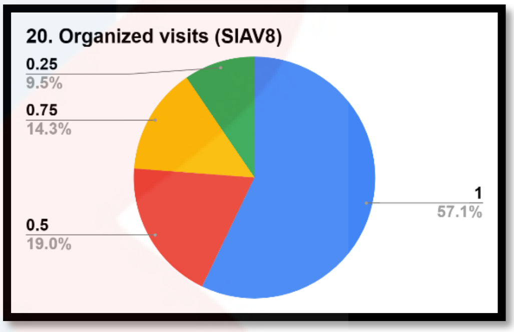

15. Additional anthropogenic values (SIAV3)
0.5
8.7%
0.75
39.1%
1
52.2%

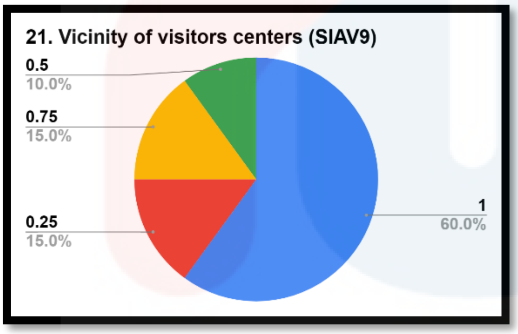

16. Vicinity of emissive centers (SIAV4)
0.5
9.5%
0.25
4.8%
0.75
28.6%
1
57.1%

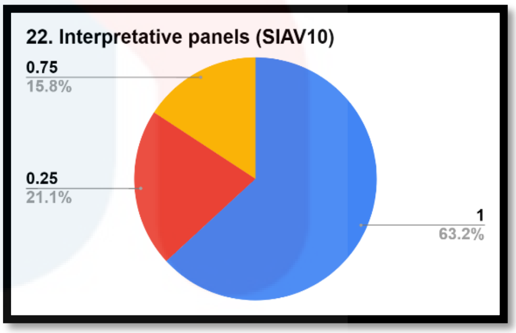

17. Vicinity of important road network (SIAV5)
0.5
18.2%
0.25
4.5%
0.75
40.9%
1
36.4%

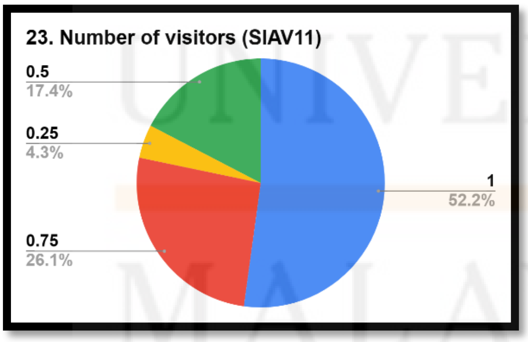

18. Additional functional values (SIAV6)
0.5
18.2%
0.75
27.3%
1
54.5%

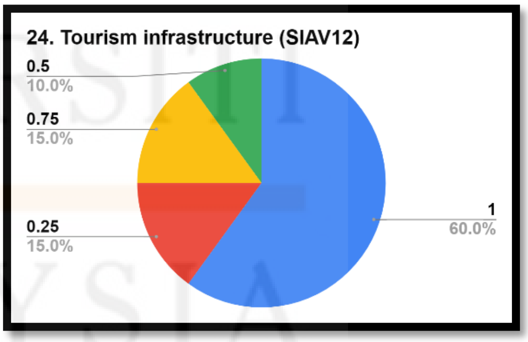

19. Promotion (SIAV7)
0.5
9.1%
0.25
9.1%
0.75
27.3%
1
54.5%

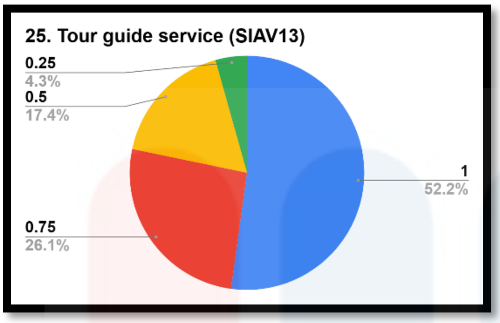

20. Organized visits (SIAV8)
0.25
9.5%
0.75
14.3%
0.5
19.0%
1
57.1%

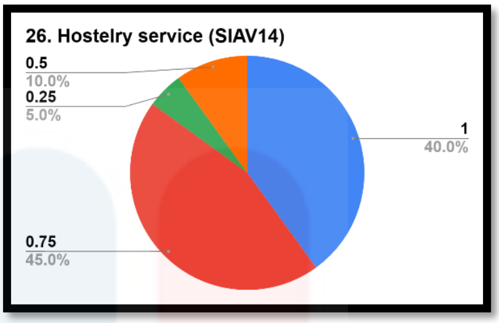

21. Vicinity of visitors centers (SIAV9)
0.5
10.0%
0.75
15.0%
0.25
15.0%
1
60.0%


22. Interpretative panels (SIAV10)
0.75
15.8%
0.25
21.1%
1
63.2%


23. Number of visitors (SIAV11)
0.5
17.4%
0.25
4.3%
0.75
26.1%
1
52.2%


24. Tourism infrastructure (SIAV12)
0.5
10.0%
0.75
15.0%
0.25
15.0%
1
60.0%


25. Tour guide service (SIAV13)
0.25
4.3%
0.5
17.4%
1
52.2%
0.75
26.1%


26. Hostelry service (SIAV14)
0.5
10.0%
0.25
5.0%
1
40.0%
0.75
45.0%

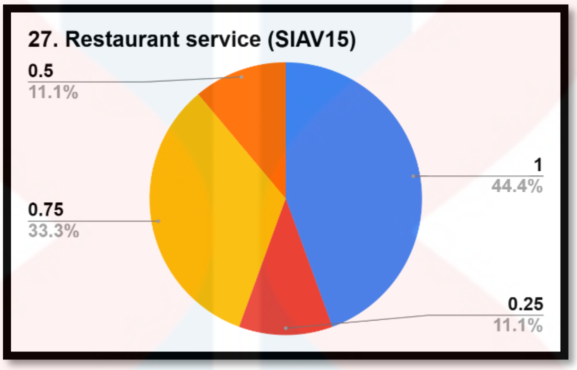

27. Restaurant service (SIAV15)
0.5
11.1%
1
44.4%
0.75
33.3%
0.25
11.1%

Table 5.1: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Kelawar).

Geosite	Values given by experts (0–1)	Im (Visitor Opinion)
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.71	0.54
Representativeness	0.72	0.58
Knowledge on geoscientific issues	0.71	0.53
Level of interpretation	0.73	0.54
Total	**[illegible]7**	**2.19**
Total Percentage (%)	**72**	**55**
Scenic/aesthetic (VSA)		
Viewpoints	0.70	0.63
Surface	0.71	0.66
Surrounding landscape and nature	0.77	0.67
Environmental fitting of sites	0.79	0.68
Total	**2.97**	**2.64**
Total Percentage (%)	**74**	**66**
Protection (VPr)		
Current condition	0.72	0.60
Protection level	0.59	0.51
Vulnerability	0.68	0.58
Suitable number of visitors	0.72	0.58
Total	**2.71**	**2.27**
Total Percentage (%)	**68**	**57**

Table 5.1. *Cont…*

Geosite	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.67	0.63
Additional natural values	0.67	0.63
Additional anthropogenic values	0.67	0.61
Vicinity of emissive centers	0.65	0.63
Vicinity of important road network	0.64	0.63
Additional functional values	0.66	0.63
Total	**3.96**	**3.76**
Total Percentage (%)	**66**	**63**
Touristic values (VTr)		
Promotion	0.69	0.66
Organized visits	0.72	0.67
Vicinity of visitor's centers	0.67	0.65
Interpretative panels	0.63	0.66
Number of visitors	0.74	0.62
Tourism infrastructure	0.72	0.7
Tour guide service	0.70	0.65
Hostelry services	0.67	0.68
Restaurant service	0.66	0.68
Total	**6.2**	**5.97**
Total Percentage (%)	**69**	**66**

Table 5.2: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Nasi Stakuh).

	Values given by experts (0–1)	**Im (Visitor Opinion)**
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.63	0.67
Representativeness	0.69	0.72
Knowledge on geoscientific issues	0.56	0.58
Level of interpretation	0.75	0.58
Total	**2.63**	**2.55**
Total Percentage (%)	**66**	**64**
Scenic/aesthetic (VSA)		
Viewpoints	0.63	0.75
Surface	0.56	0.75
Surrounding landscape and nature	0.69	0.67
Environmental fitting of sites	0.63	0.58
Total	**2.51**	**2.75**
Total Percentage (%)	**63**	**69**
Protection (VPr)		
Current condition	0.56	0.67
Protection level	0.44	0.58
Vulnerability	0.56	0.67
Suitable number of visitors	0.56	0.67
Total	**2.12**	**2.59**
Total Percentage (%)	**53**	**65**

Table 5.2: *Cont…*

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.44	0.67
Additional natural values	0.56	0.67
Additional anthropogenic values	0.44	0.75
Vicinity of emissive centers	0.44	0.75
Vicinity of important road network	0.44	0.75
Additional functional values	0.44	0.75
Total	**2.76**	**4.34**
Total Percentage (%)	**46**	**72**
Touristic values (VTr)		
Promotion	0.44	0.75
Organized visits	0.44	0.75
Vicinity of visitor's centers	0.44	0.75
Interpretative panels	0.44	0.75
Number of visitors	0.44	0.75
Tourism infrastructure	0.38	0.75
Tour guide service	0.38	0.67
Hostelry services	0.38	0.67
Restaurant service	0.5	0.67
Total	**3.84**	**6.51**
Total Percentage (%)	**43**	**72**

Table 5.3: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Batu Balai).

	Values given by experts (0–1)	**Im (Visitor Opinion)**
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.56	0.79
Representativeness	0.81	0.79
Knowledge on geoscientific issues	0.69	0.67
Level of interpretation	0.75	0.71
Total	**2.81**	**2.96**
Total Percentage (%)	**70**	**74**
Scenic/aesthetic (VSA)		
Viewpoints	0.44	0.79
Surface	0.69	0.67
Surrounding landscape and nature	0.75	0.79
Environmental fitting of sites	0.81	0.75
Total	**2.69**	**3**
Total Percentage (%)	**67**	**75**
Protection (VPr)		
Current condition	0.56	0.83
Protection level	0.44	0.71
Vulnerability	0.56	0.83
Suitable number of visitors	0.31	0.75
Total	**1.87**	**3.12**
Total Percentage (%)	**47**	**78**

Table 5.3: *Cont…*

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.44	0.75
Additional natural values	0.63	0.75
Additional anthropogenic values	0.5	0.75
Vicinity of emissive centers	0.44	0.74
Vicinity of important road network	0.38	0.83
Additional functional values	0.38	0.83
Total	**2.77**	**4.65**
Total Percentage (%)	**46**	**78**
Touristic values (VTr)		
Promotion	0.44	0.71
Organized visits	0.44	0.83
Vicinity of visitor's centers	0.44	0.75
Interpretative panels	0.5	0.79
Number of visitors	0.44	0.75
Tourism infrastructure	0.75	0.79
Tour guide service	0.56	0.75
Hostelry services	0.38	0.83
Restaurant service	0.38	0.75
Total	**4.33**	**6.95**
Total Percentage (%)	**48**	**77**

Table 5.4: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Kawah).

	Values given by experts (0–1)	**Im (Visitor Opinion)**
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.5	0.38
Representativeness	0.44	0.38
Knowledge on geoscientific issues	0.5	0.38
Level of interpretation	0.75	0.38
Total	**2.19**	**1.52**
Total Percentage (%)	**55**	**38**
Scenic/aesthetic (VSA)		
Viewpoints	0.44	0.38
Surface	0.69	0.38
Surrounding landscape and nature	0.5	0.5
Environmental fitting of sites	0.5	0.5
Total	**2.13**	**1.76**
Total Percentage (%)	**53**	**44**
Protection (VPr)		
Current condition	0.44	0.56
Protection level	0.61	0.44
Vulnerability	0.61	0.56
Suitable number of visitors	0.4	0.4
Total	**2.06**	**1.96**
Total Percentage (%)	**52**	**49**

Table 5.4: *Cont…*

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.5	0.44
Additional natural values	0.69	0.44
Additional anthropogenic values	0.56	0.38
Vicinity of emissive centers	0.56	0.38
Vicinity of important road network	0.5	0.38
Additional functional values	0.31	0.31
Total	**3.12**	**2.33**
Total Percentage (%)	**52**	**39**
Touristic values (VTr)		
Promotion	0.75	0.44
Organized visits	0.5	0.44
Vicinity of visitor's centers	0.56	0.44
Interpretative panels	0.69	0.44
Number of visitors	0.5	0.44
Tourism infrastructure	0.5	0.44
Tour guide service	0.75	0.5
Hostelry services	0.56	0.44
Restaurant service	0.69	0.38
Total	**5.5**	**3.96**
Total Percentage (%)	**61**	**44**

Table 5.5: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Paha Kerbau).

	Values given by experts (0–1)	**Im (Visitor Opinion)**
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.56	0.94
Representativeness	0.63	0.94
Knowledge on geoscientific issues	0.56	0.94
Level of interpretation	0.63	0.93
Total	**2.38**	**3.75**
Total Percentage (%)	**60**	**94**
Scenic/aesthetic (VSA)		
Viewpoints	0.63	0.88
Surface	0.56	0.81
Surrounding landscape and nature	0.69	0.69
Environmental fitting of sites	0.69	0.94
Total	**2.57**	**3.32**
Total Percentage (%)	**64**	**83**
Protection (VPr)		
Current condition	0.88	0.88
Protection level	0.56	0.75
Vulnerability	0.56	0.88
Suitable number of visitors	0.5	0.75
Total	**2.5**	**3.26**
Total Percentage (%)	**63**	**82**

Table 5.5: *Cont…*

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.5	0.69
Additional natural values	0.63	0.89
Additional anthropogenic values	0.69	0.89
Vicinity of emissive centers	0.63	0.69
Vicinity of important road network	0.56	0.75
Additional functional values	0.56	0.69
Total	**3.57**	**4.6**
Total Percentage (%)	**60**	**77**
Touristic values (VTr)		
Promotion	0.56	0.69
Organized visits	0.63	0.75
Vicinity of visitor's centers	0.69	0.75
Interpretative panels	0.5	0.75
Number of visitors	0.56	0.75
Tourism infrastructure	0.5	0.69
Tour guide service	0.63	0.56
Hostelry services	0.5	0.69
Restaurant service	0.5	0.69
Total	**5.07**	**6.32**
Total Percentage (%)	**56**	**70**

Table 5.6: Values assigned to each sub indicator in the GAM model by experts and visitors (Gua Kurap).

	Values given by experts (0–1)	**Im (Visitor Opinion)**
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.7	0.92
Representativeness	0.75	0.92
Knowledge on geoscientific issues	0.7	0.92
Level of interpretation	0.8	0.92
Total	**2.95**	**3.68**
Total Percentage (%)	**74**	**92**
Scenic/aesthetic (VSA)		
Viewpoints	0.65	0.92
Surface	0.7	1
Surrounding landscape and nature	0.85	1
Environmental fitting of sites	0.8	1
Total	**3**	**3.92**
Total Percentage (%)	**75**	**98**
Protection (VPr)		
Current condition	0.7	0.25
Protection level	0.6	0.92
Vulnerability	0.7	0.92
Suitable number of visitors	0.55	0.92
Total	**2.55**	**3.01**
Total Percentage (%)	**64**	**75**

Table 5.6: *Cont…*

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.55	0.92
Additional natural values	0.7	0.92
Additional anthropogenic values	0.6	0.92
Vicinity of emissive centers	0.5	0.92
Vicinity of important road network	0.92	0.92
Additional functional values	0.92	0.92
Total	**4.19**	**5.52**
Total Percentage (%)	**70**	**92**
Touristic values (VTr)		
Promotion	0.92	0.92
Organized visits	0.5	0.92
Vicinity of visitor's centers	0.45	0.92
Interpretative panels	0.4	0.92
Number of visitors	0.5	0.92
Tourism infrastructure	0.45	0.92
Tour guide service	0.6	0.92
Hostelry services	0.45	0.92
Restaurant service	0.35	0.92
Total	**4.62**	**8.28**
Total Percentage (%)	**51**	**92**

Table 5.7: Overall geomorphological sites by M-GAM (Assessment done by Expertise).

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection(VPR)	Total Main Value (∑)
Gua Kelawar	2.87	2.97	2.71	8.55
Gua Nasi Stakuh	2.63	2.51	2.12	7.26
Gua Batu Balai	2.81	2.69	1.87	7.37
Gua Kawah	2.19	2.13	2.06	6.38
Gua Paha Kerbau	2.38	2.57	2.5	7.45
Gua Kurap	2.95	3.0	2.55	8.5

Table 5.7: *Cont…*

Additional Values (AV)			
Geosites	Functional values (VFns)	Touristic values (VTr)	Total Additional Value (∑)
Gua Kelawar	3.96	6.2	10.16
Gua Nasi Stakuh	2.76	3.84	6.6
Gua Batu Balai	2.77	4.33	7.1
Gua Kawah	3.12	5.5	8.62
Gua Paha Kerbau	3.57	5.07	8.64
Gua Kurap	4.19	4.62	8.81

Table 5.8: Overall geomorphological sites by M-GAM (Assessment done by Tourists).

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection(VPR)	Total Main Value (∑)
Gua Kelawar	2.19	2.64	2.27	7.1
Gua Nasi Stakuh	2.55	2.75	2.59	7.9
Gua Batu Balai	2.96	3.0	3.12	9.1
Gua Kawah	1.52	1.76	1.96	5.2
Gua Paha Kerbau	3.75	3.32	3.26	10.3
Gua Kurap	3.68	3.92	3.01	10.6

Table 5.8: *Cont…*

Additional Values (AV)			
Geosites	Functional values (VFns)	Touristic values (VTr)	Total Additional Value
Gua Kelawar	3.76	5.97	9.73
Gua Nasi Stakuh	4.34	6.51	10.9
Gua Batu Balai	4.65	6.95	11.6
Gua Kawah	2.33	3.96	6.3
Gua Paha Kerbau	4.6	6.32	10.9
Gua Kurap	5.52	8.28	13.8

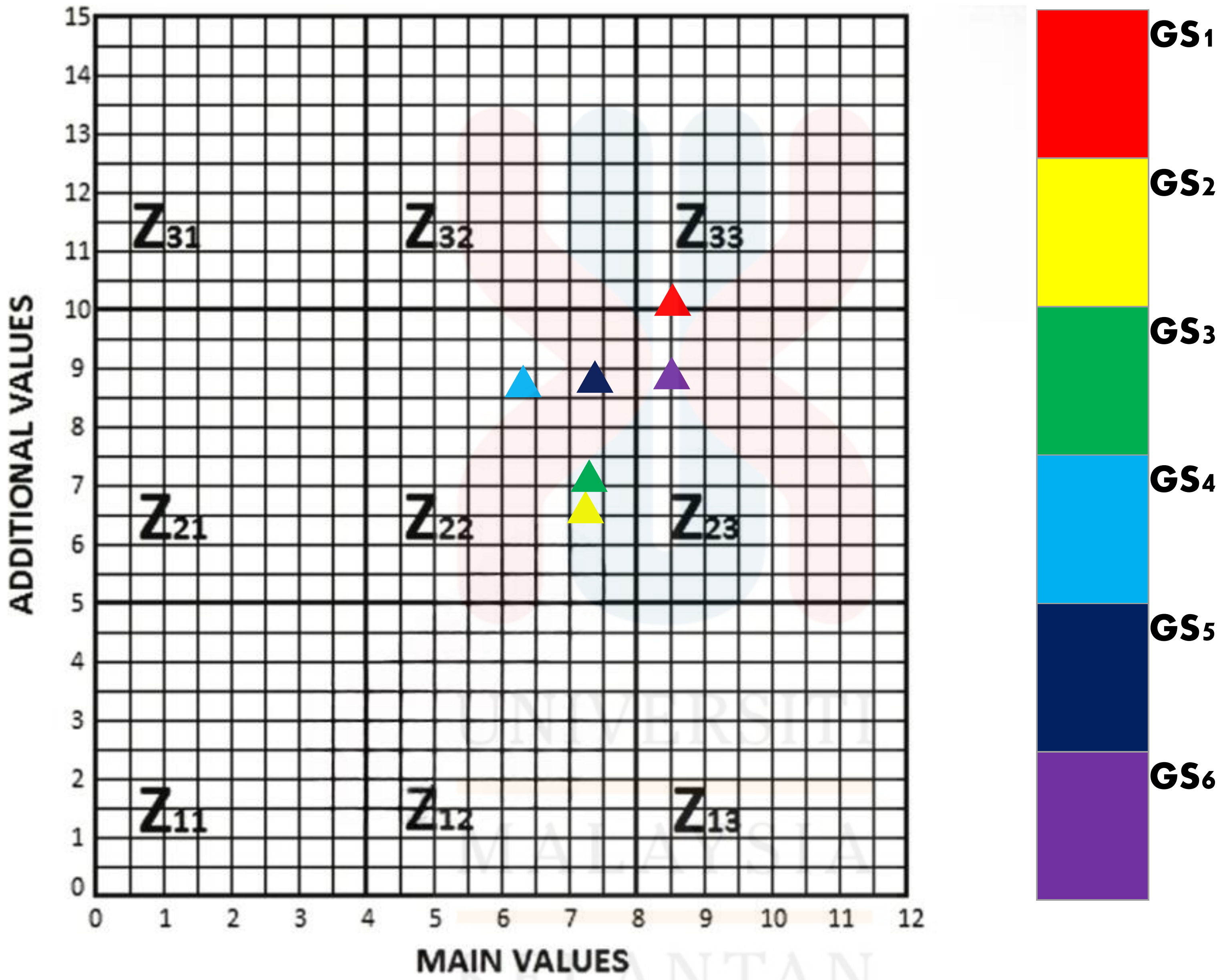


Figure 5.1: Position of geosites in M-GAM matrix (Experts).

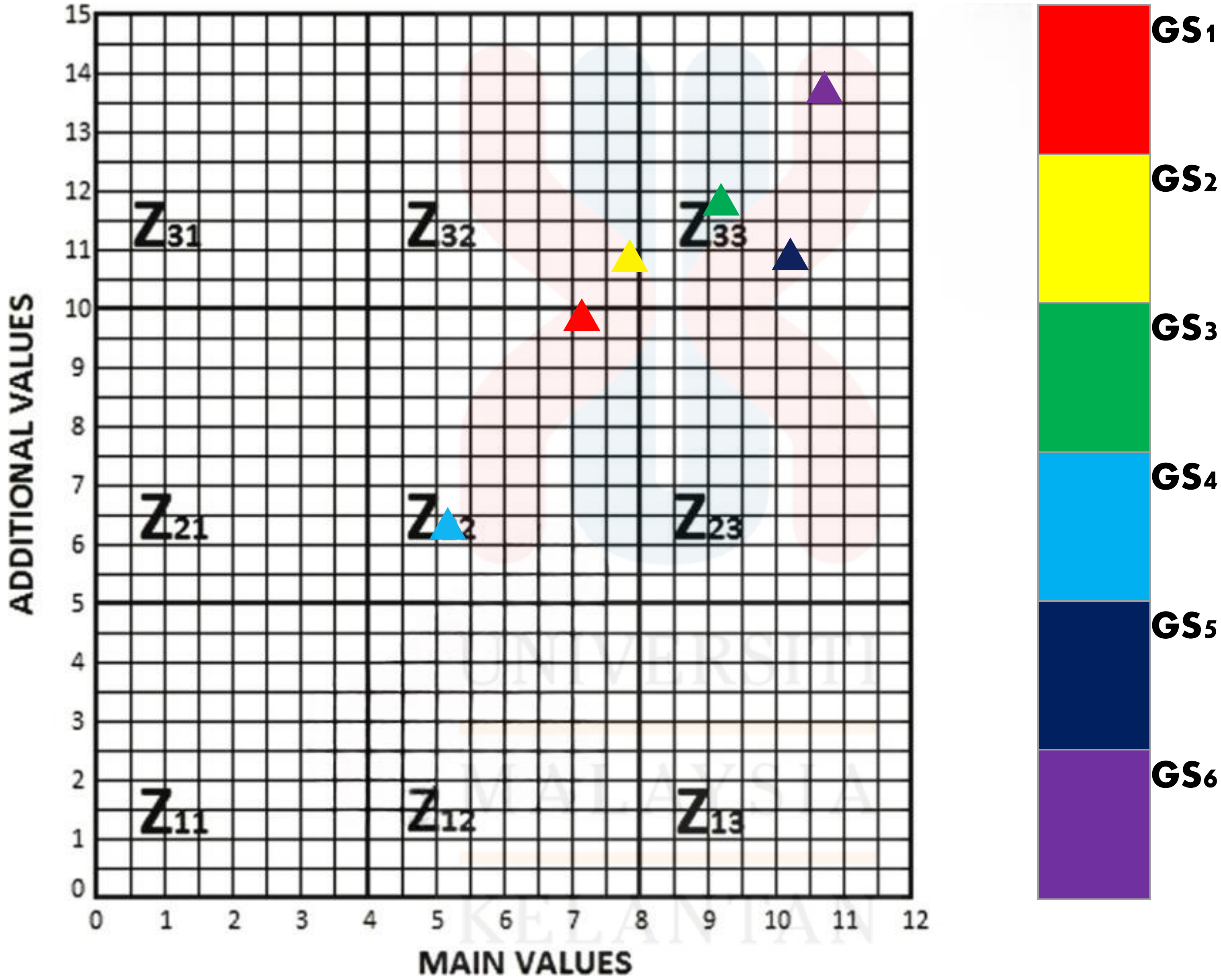


Figure 5.2: Position of geosites in M-GAM matrix (Tourists).

5.4 Karst Geomorphology

The karst geomorphology of the study area in Dabong, Kelantan can be studied by analyzing the landforms in the area and the processes that have formed them. This may include mapping the distribution and morphology of karst features such as caves, sinkholes, and towers, as well as studying the geology, hydrology, and erosion history of the area.

Karst geomorphology is the study of the landforms and processes that shape the surface of the earth in areas underlain by soluble rocks such as limestone and dolomite. Karst landscapes are characterized by a distinctive set of landforms, such as caves, sinkholes, and towers, that are formed by the dissolution of the rock by groundwater.

The process of karstification begins with the weathering of the rock surface by rainwater, which forms small channels and depressions in the rock. These channels and depressions then become larger as the rock is dissolved by the groundwater. The dissolved rock is carried away by the groundwater, creating underground drainage systems and caves.

Over time, the landscape is shaped by the collapse of the roofs of these caves, creating sinkholes and dolines, and the erosion of the rock by the groundwater, creating towers and other landforms.

The geomorphology of a karst area can be influenced by a variety of factors, including the type and structure of the rock, the climate, and the rate of erosion. For example, a karst area with a high rate of precipitation will have a different geomorphology than an area with a low rate of precipitation.

5.5 Geomorphological Structure Inside cave

The geomorphological structure inside a cave refers to the physical characteristics and features of the cave, including the shape and layout of the cave passages, the size and distribution of speleothems (cave formations), and the rock types and structures present within the cave.

Some common geomorphological structures found inside caves include:

- Stalactites and Stalagmites

  These are common cave formations that hang from the ceiling or rise from the floor of a cave, respectively. They are formed by the precipitation of minerals from water droplets that fall from the ceiling or rise from the floor.

- Columns

  A column is a vertical structure that forms when a stalactite and a stalagmite grow towards each other and eventually join to form a single structure.

- Flowstone

  Flowstone is a type of speleothem that forms from the precipitation of minerals from water flowing over a surface.

a) **Gua Kelawar**

Figure 5.3: Flowstone at Gua Kelawar.

b) Gua Batu Balai

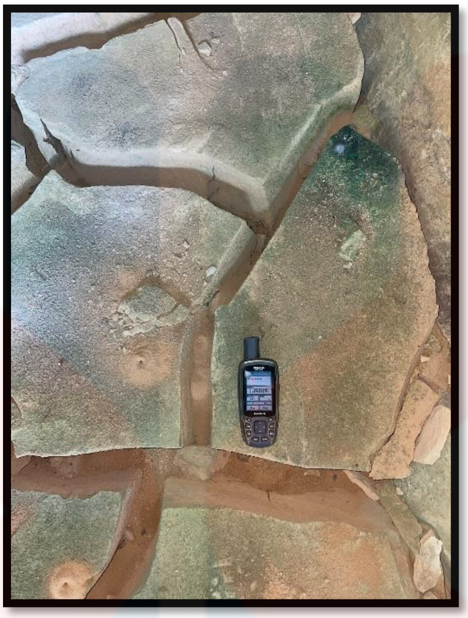


Figure 5.4: Mud crack in Gua Batu Balai.

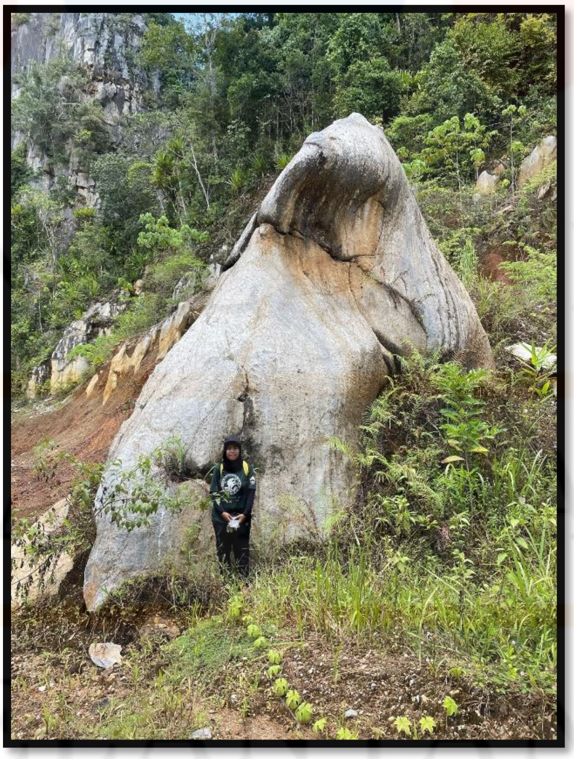


Figure 5.5: Outcrop near Gua Batu Balai.

c) Gua Nasi Stakuh

Figure 5.6: Cave entry of Gua Nasi Stakuh.

d) Gua Kurap

Figure 5.7: Mud crack in Gua Kurap.

e) Gua Kawah

Figure 5.8: View of Gua Kawah.

f) Gua Paha Kerbau

Figure 5.9: View of Gua Paha Kerbau.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Study area in Dabong, Kelantan has karst landforms that are suitable for geoheritage, it means that the area has geological and geomorphological features that are of significant scientific, cultural, and/or aesthetic value. These features can provide important information about the Earth's history and evolution, as well as offer opportunities for education and tourism.

Karst landforms, such as caves are unique and visually striking features that can attract visitors and tourists. These features can also host a wide range of biodiversity and have an important role in regulating the local climate and hydrology.

The study area in Dabong, Kelantan can be a potential geosite if the karst landform is suitable for geoheritage. The modified Geosite Assessment Model (M-GAM) had been used in this study, and the results are showing that some of the cave had a potential to become a geosite of karsts features.

By referring to the M-GAM matrix focusing on results from expertise, it shows that GS1 (representing for Gua Kelawar) had the highest values for MV and AV. MV - sub indicator of Scenic/Aesthetic (VSA) = 2.97, AV – sub indicator of Touristic Value (VTr) = 6.2. By referring to the M-GAM matrix focusing on results from tourists, it shows that GS6 (representing for Gua Kurap) had the highest values for MV and AV. MV - sub indicator of Scenic/Aesthetic (VSA) = 3.92, AV – sub indicator of Touristic Value (VTr) = 8.28

GS1 has the high in Scenic/Aesthetic value of the study area which indicate that the area has a visually pleasing and attractive appearance. The area would likely contain natural features such as beautiful landscapes, rock formations, and water bodies that are considered to be visually appealing. A high Scenic/Aesthetic value would also suggest that the area has a high potential to attract visitors and tourists, which would have an impact on the local economy and community. The area could be developed into a tourist destination, with potential for recreational activities such as hiking, camping, and sightseeing (An et al., 2019).

6.2 Recommendations

Based on the M-GAM methods and the information provided from the questionnaire survey, it is likely that the study area in Dabong, Kelantan has karst landforms that can be a potential geosite (Carrión-Mero et al., 2022).

Following recommendations can be made to enhance the geosite potential:

- **Developing a management plan**

  A management plan should be developed to ensure that the karst landforms are protected and conserved for future generations. This plan should include measures to control human impact on the karst landforms, such as limiting access and regulating activities within the geosite.

- **Improving accessibility and infrastructure**

The accessibility and infrastructure of the geosite should be improved to make it more attractive to visitors and tourists. This can include building roads, trails, and visitor centers, as well as providing information and interpretation services.

- **Enhancing the educational and research value**

  The educational and research value of the geosite can be enhanced by providing opportunities for geological, geomorphological, and hydrological research, and by developing educational programs and materials for visitors and tourists.

- **Promoting the area**

  The geosite should be promoted to attract visitors and tourists. This can include creating a website, social media presence and brochures, as well as participating in tourism fairs and events.

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APPENDIX A: QUESTIONNAIRE

EVALUATION OF POTENTIAL GUA KELAWAR KARSTS, DABONG DISTRICT, KELANTAN.

Assalamualaikum and Greetings to all dear respondents,

I am final year students from Faculty of Earth Science (FSB), Universiti Malaysia Kelantan (UMK) pursuing Degree in Bachelor of Applied Science (Geoscience) with Honors. I'm currently conducting a research survey regarding "**GEOLOGY AND GEOSITE POTENTIAL OF KARSTS IN KAMPUNG BATU UDANG, DABONG DISTRICT, KELANTAN".**

I would appreciate if you could spare approximately 10 minutes of your time to complete this questionnaire. Your participation in this study is completely voluntary. The completion and return of the attached questionnaire is taken to constitute your consent to participate in the study.

Your participation with this study would be highly appreciated. I guarantee that your response will be kept fully private and used exclusively for academic purposes. Your private information won't be shared or used for anything but academic research.

Thank you for your valuable time, attention and cooperation.

Regards,
Nur Syuhadah Binti Lazim

*Required

1. 1. Gender *

Mark only one oval.

- ( ) Male
- ( ) Female

2. 2. Age (years) *

Mark only one oval.

- 17-21
- 22-25
- 26-29
- 30 and above

3. 3. Level of education *

Mark only one oval.

- School
- Diploma
- Degree
- Doctorate

EVALUATION OF POTENTIAL GUA KELAWAR KARSTS, DABONG DISTRICT, KELANTAN.

4. 1. Gender *

Mark only one oval.

- Male
- Female

5. 2. Age (years) *

Mark only one oval.

- 17-21
- 22-25
- 26-29
- 30 and above

6. 3. Level of education *

Mark only one oval.

- School
- Diploma
- Degree
- Doctorate

Section 2 of 3

SCIENTIFIC/EDUCATIONAL VALUE (VSE)

7. 1. Rarity - Number of closest identical sites.

Mark only one oval.

0

1
2
3
4
5

1

8. 2. Representativeness (Didactic and exemplary characteristics of the site due to its own quality and general configuration).

Mark only one oval.

0
1 ◯
2 ◯
3 ◯
4 ◯
5 ◯
1

9. 3. Knowledge on geoscientific issues (Number of written papers in acknowledge journals, thesis, presentations, and other publications).

Mark only one oval.

0

1

2

3

4

5

1

10. 4. Level of interpretation (Level of interpretative possibilities on geological and geomorphological process, phenomena and shapes and level of scientific knowledge).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

1

SCENIC/AESTHETIC (VSA)

11. 5. Viewpoints (Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site. Eg: has a walkway for walking)

Mark only one oval.

0
1
2
3
4
5
1

12. 6. Surface (Whole surface of the site. Each site is considered in quantitative relation to other sites).

Mark only one oval.

0

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

1

13. 7. Surrounding landscape and nature (Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban area, etc).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

1

14. 8. Environmental fitting of sites (Level of contrast to the nature, contrast of colors, appearance of shapes, etc).

Mark only one oval.

0
1 ◯
2 ◯
3 ◯
4 ◯
5 ◯
1

PROTECTION (VPr)

15. 9. Current condition (Current state of geosite).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

1

16. 10. Protection level (Protection by local or regional groups, national government, international organizations, etc).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

1

17. 11. Vulnerability (Vulnerability level of geosite. Eg: Difficulty to access, the presence of access controls or restrictions, protected areas).

Mark only one oval.

0

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

1

18. 12. Suitable number of visitors (Proposed number of visitors on the site at the same time, according to the surface area, vulnerability, and current state of geosite).

Mark only one oval.

0

1

2

3

4

5

1

SECTION B - ADDITIONAL VALUES (AVs)

19. 13. Accessibility (Possibilities of approaching to the site).

Mark only one oval.

	0
1	◯
2	◯
3	◯
4	◯
5	◯
	1

20. 14. Additional natural values (Number of additional natural values in the radius of 5 km including geosite).

Mark only one oval.

0

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

1

21. 15. Additional anthropogenic values (Number of additional anthropogenic values in the radius of 5 km at Dabong) Anthropogenic : something that is made by humans such as excessive greenhouse gasses).

Mark only one oval.

	0
1	◯
2	◯
3	◯
4	◯
5	◯
	1

22. 16. Vicinity of emissive centers (Dabong has an updated facilities management).

Mark only one oval.

0

1

2

3

4

5

1

23. 17. Vicinity of important road network (Dabong near to the important road networks within the 20 km radius).

Mark only one oval.

	0
1	◯
2	◯
3	◯
4	◯
5	◯
	1

24. 18. Additional functional values (Dabong has a lot of parking lot, gas stations, mechanics, etc).

Mark only one oval.

0	
1	◯
2	◯
3	◯
4	◯
5	◯
1	

TOURISM VALUES (VTr)

25. 19. Promotion (Dabong has high level and number of promotional resources).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

1

26. 20. Organized visits (Annual number of organized visits to the geosite).

Mark only one oval.

0

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

1

27. 21. Vicinity of visitor's centre (Dabong has tourist information centre. It provided the visitors a locations with informations on the area's attractions, lodgings, maps, and other items relevant to tourism.

Mark only one oval.

0

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

1

28. 22. Interpretative panels (Interpretative charachteristics of text and graphics material quality, size, fitting to surroundings, etc).

Mark only one oval.

0

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

1

29. 23. Number of visitors (Dabong has a lot number of visitors).

Mark only one oval.

0

1

2

3

4

5

1

30. 24. Tourism infrastructure (Dabong has high level of additional infrastructure for tourist such as pedestrian pathways, resting places, garbage cans, toilets, etc).

Mark only one oval.

0

1

2

3

4

5

1

31. 25. Tour guide service (If exists, expertise level, knowledge of foreign language (s), interpretative skills, etc).

Mark only one oval.

0

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

1

32. 26. Hostelry service (Hostelry service close to geosite).

Mark only one oval.

0
1
2
3
4
5
1

33. 27. Restaurant service (Restaurant service is close to geosite)

Mark only one oval.

0
1
2
3
4
5
1